

## Appendix D CalSim-II Model

### CalSim-II Software

CalSim-II was developed using the Water Resources Integrated Modeling Software (WRIMS), which is an optimization linear programming (LP)/mixed integer linear programming (MILP) solver that determines an optimal set of decisions for each time period given a set of weights and system constraints. The physical description of the system is expressed through a user interface with tables outlining the system characteristics. The priority weights and basic constraints are also entered in the system tables. The programming language used, Water Resources Engineering Simulation Language (WRESL), serves as an interface between the user and the LP/MILP solver, time-series database, and relational database. Specialized operating criteria are expressed in WRESL.

### Key Processes

CalSim-II is a planning model developed by the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation). It simulates the State Water Project (SWP) and the Central Valley Project (CVP) and areas tributary to the Sacramento-San Joaquin Delta. CalSim-II provides quantitative hydrologic-based information to those responsible for planning, managing and operating the State Water Project (SWP) and the federal CVP. As the official model of those projects, CalSim-II is typically the system model that is used for any inter-regional or statewide analysis in California. CalSim-II uses described optimization techniques to route water through a CVP-SWP system network representation. The network includes over 300 nodes and over 900 arcs, representing 24 surface reservoirs and the interconnected flow system.

The model operates on a monthly time step from water year 1992 through 2003. Using historical rainfall and runoff data, which has been adjusted for changes in water and land use that have occurred or may occur in the future, the model simulates the operation of the water resources infrastructure in the Sacramento and San Joaquin river basins on a month-to-month basis during this 82-year period. In the model, the reservoirs and pumping facilities of the SWP and CVP are operated to assure the flow and water quality requirements for these systems are met. The model assumes that facilities, land use, water supply contracts, and regulatory requirements are constant over 82 years from 1922 to 2003, representing a fixed level of development.

The model operates in six or seven steps to simulate the different regulatory regimes: D1485, D1641, B2, Joint Point of Diversion (JPOD), EWA, and EWA2 if needed.

OCAP Study 7.0 is a 6-step study, incorporating a full EWA representation with the same set of assets and actions developed for the Common Assumptions Model Common Model Package. OCAP Studies 7.1 and 8.0 use a 7-step limited EWA representation where the only purchase is from the Yuba Basin, export actions are confined to the VAMP- and possibly post-VAMP May shoulder periods, and the size of the actions are tailored to the available asset so as to discourage any occurrence of carry over storage debt at San Luis.

The results from the final case of the position analysis (EWA or EWA2) is accepted as the end-of-year system state, and serve as the initial conditions for each of the cases in the following year's analysis. The general modeling procedure is outlined below, and shown in Figure 1:

1. Run the D1641 simulation for Oct-Sep of the current water year.
2. Run the D1485 simulation for Oct-Sep of the current water year and compute annual water costs for implementing D1641 operations relative to D1485 operations (i.e., Water Quality Control Plan [WQCP] costs).
3. Run the B2 simulation for Oct-Sep of the current water year, dynamically accounting for the (b)(2) account balance with knowledge of annual WQCP costs, and implementing fish protection actions according to preferences defined for OCAP.
4. Run the CONV simulation for Oct-Sep of the current water year, repeating B2 actions from Step 3, assessment of JPOD capacity, and simulated CVP usage of 50 percent of JPOD capacity.
5. Run the TXFR simulation for the Oct-Sep of the current year, reflecting transfer operations.
6. Run the EWA simulation for Oct-Sep of the current water year, repeating B2 actions from Step 3, repeating CVP usage of 50 percent of JPOD capacity from Step 4, taking EWA actions, comparing Step 4 and 5 results to assess EWA debt, and managing EWA debt through acquisition and application of assets (e.g., SWP transfer or 50 percent of B2 gains to EWA, EWA usage of 50 percent of JPOD capacity, fixed purchases north and south of Delta).
7. Run the EWA2 simulation to use the limited EWA representation (Study 7.1 and 8.0 only)
8. Accept the state of the system from the end of September in Step 6 or 7 as the initial condition for the following year's analysis cases (i.e., D1641, D1485, B2, JPOD, and EWA).

Repeat all above steps for every year of the period of record.

### Annual CalSim-II Step Procedure: Oct-Sep

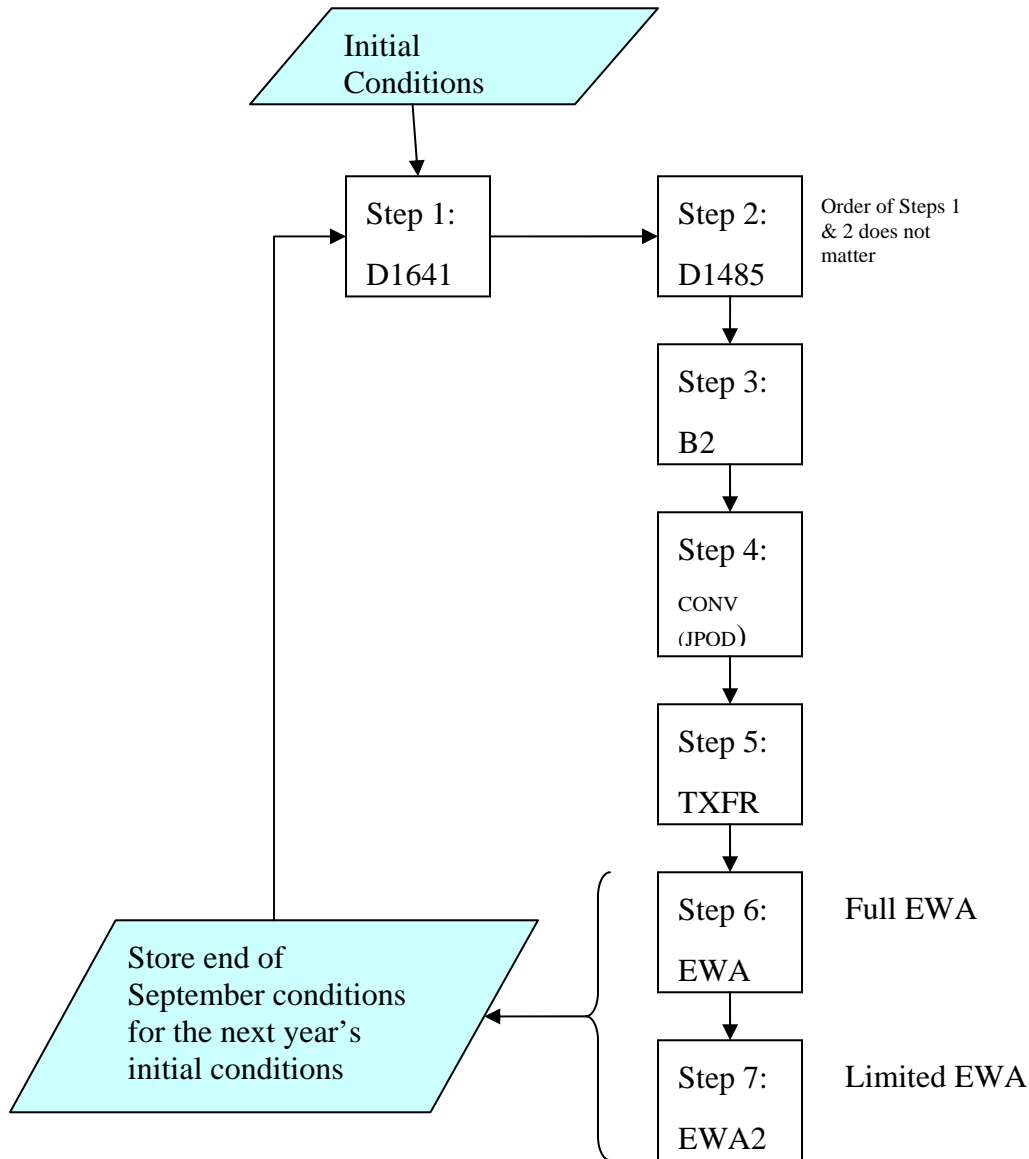


Figure 1. CalSim-II Procedure to Simulate EWA Operations (Study 7.0 only uses the first six steps)

#### Hydrology

Reservoir inflows, stream gains, diversion requirements, irrigation efficiencies, return flows and groundwater operation are all components of the hydrology for CalSim-II.

The monthly step simulations are conducted over the 82-year period (1922 – 2003) of the adjusted historical rainfall/runoff data. This approach incorporates the over-arching assumption that the next 82 years will have the same rainfall/snowmelt amount and pattern, both within-year and from year to year, as the period 1922 through 2003.

## Demands

Demands are preprocessed independent of CalSim-II and may vary according to the specified level of development (e.g. 2005, 2030) and according to hydrologic conditions. They are typically input into the model as a monthly time series. Demands are classified as CVP project, SWP project, local project or non-project. CVP and SWP demands are separated into different classes based on contract type.

**Table 1. Summary of SWP and CVP Demands (TAF/Year)**

Project	North Of Delta	South of Delta
	<b>Existing</b>	
CVP Contracts		
• Settlement/Exchange	2,194	840
Water Service Contracts		
• Agriculture	378	1,927
• M&I <sup>1</sup>	356	164
• Refuges	157	305
SWP Contracts		
• Feather River Service Area	796	0
• Agriculture	0	1,048
• M&I	108	3,008
	<b>Future</b>	
CVP Contracts		
• Settlement/Exchange	2,194	840
Water Service Contracts		
• Agriculture	378	1,937
• M&I <sup>1</sup>	557	164

<sup>1</sup> North of Delta CVP M&I demands include Delta demands

• Refuges	189	281
SWP Contracts		
• Feather River Service Area	796	0
• Agriculture	0	1,032
• M&I	114	3,024

## Agricultural Demands

Demands in the Sacramento River Basin (including the Feather and American River basins) and Delta are determined based on land use and vary by month and year according to hydrologic conditions. Land use-based demands are calculated using the Consumptive Use (CU) model. The model simulates soil moisture conditions for 13 different crop types over the historical period.

Irrigation demand is triggered when soil moisture falls below a specified minimum. The CU model calculates the crop consumptive use of applied water. The consumptive use is subsequently multiplied by water use efficiency factors to obtain a regional water requirement to be met from stream diversions or groundwater pumping. Agricultural demands in the Delta are represented more simply as an overall mass balance between precipitation and crop evapotranspiration.

CVP and SWP agricultural demands south of the Delta are based on contract amounts. CVP demands south of the Delta are assumed to be fixed at maximum contract amount and do not vary year to year. SWP agricultural demands in the San Joaquin Valley are capped to the full assigned amount, but are reduced in wetter years using an index developed from annual Kern River inflows to Lake Isabella.

In CalSim-II non-recoverable losses are assumed to be 10 to 15 percent of the crop consumptive use of applied water. Non-recoverable loss factors are used to determine the portion of the supply that will return to the system as surface return flow or as deep percolation to groundwater. Efficiency factors may vary by month and by year.

## M&I Demands

Indoor urban water use is considered non-consumptive and is ignored by the model. Outdoor urban water use is treated as an irrigation demand and is combined with the agricultural demands. M&I diversions, although not entirely consumptive, can have a large influence on reservoir operations.

However, both indoor and outdoor M&I surface water diversions have therefore been included in CalSim-II for the American and Lower Sacramento River areas because they partially determine the operation of Folsom Lake. Outdoor urban demand is calculated by the CU model, with the

irrigated area computed as a fixed fraction of the total urban area as measured by DWR in land use surveys.

CVP and SWP south of Delta M&I demands are based on contract amounts. CVP demands are assumed to equal contract amounts and do not vary. SWP M&I demands south of the Delta are split into Metropolitan Water District of Southern California (MWDSC) and others. MWDSC demands are either set at full contract amounts or are determined through a process of iteration between CalSim-II and MWDSC's integrated resource planning simulation (IRPSIM) model, and vary from year to year. Other SWP M&I contractors' demands are fixed at their full designated amount.

## Project/Non-Project Split

Demands are disaggregated in CalSim-II into project demands and non-project demands. Project demands are subject to reduced water allocations based on CVP and SWP contract provisions, while non-project demands are satisfied from sources other than project storage and project conveyance facilities and are reduced as a function of water availability in the absence of project operations. For each Depletion Study Area (DSA), project demands are calculated as a fixed percentage of the total land use-based demand. The split between project and nonproject demands was determined by comparing project acreage within each DSA to the total crop acreage within the DSA.

## Environmental Water Requirements

Environmental water requirements such as minimum reservoir storage requirements, minimum in-stream flows and deliveries to national wildlife refuges, and wildlife management areas that are stipulated in current regulatory requirements and discretionary interagency agreements are included in the model where appropriate. See Section g. for a description of regulatory requirements.

### Allocation Decisions

The water allocation process must consider the various categories of water demands and the contractual amounts and deficiency criteria associated with each. These water demands may be categorized as follows: (1) Water Rights Settlement Agreements; (2) Municipal and Industrial Water Service Contracts; (3) Legislative Mandates; (4) Agricultural Water Service Contracts; and (5) Delivery Losses.

CalSim-II uses allocation logic for determining deliveries to north-of-Delta and south-of-Delta CVP and SWP contractors. The delivery logic uses runoff forecast information, which incorporates uncertainty and standardized rule curves (i.e. Water Supply Index versus Demand Index Curve). The rule curves relate forecasted water supplies to deliverable "demand," and then use deliverable "demand" to assign subsequent delivery levels to estimate the water available for delivery and carryover storage. Updates of delivery levels occur monthly from January 1 through May 1 for the SWP and March 1 through May 1 for the CVP as runoff forecasts become more certain. The south-of-Delta SWP delivery is determined based on water supply parameters and operational constraints. The CVP system wide delivery and south-of-Delta delivery are

determined similarly upon water supply parameters and operational constraints with specific consideration for export constraints.

### **Reservoir System Operation**

The CalSim-II model represents reservoirs and channels as a network of nodes and arcs. Water storage and release decisions are made through arcs. Weights on the decision variables encourage (positive weight) or discourage (negative weight) the solver to allocate water to the specified variable. The weight is a measure of the relative allocation priority for consumptive or non-consumptive uses. Storage arc zones are weighted separately to describe the operation rules of a reservoir in concert with upstream and downstream water uses.

CalSim-II requires operating rules to release flows to meet water demands and water quality standards. Reservoirs are operated through the year using rule curves that represent the desired storage levels according to flood-space filling requirements. The rule curves have been derived from historic hydrologic conditions and hence may not be appropriate if there are significant changes to system operations or changes from the historical reservoir inflow hydrology.

Each reservoir node is divided into five zones representing operational volumes. In general the zones are dead pool, lower conservation pool, intermediate conservation pool, upper conservation pool, and flood control pool. The maximum reservoir release is determined by the hydraulic properties of the outlet works and may be expressed as a piece-wise linear function of storage.

Reservoirs provide flood control space during the winter wet season, when they need to have flood space requirements. This flood control space requirement limits the amount of water stored during the wet season.

CalSim-II sets targets for San Luis storage each month that are dependent on the current South of Delta allocation and upstream reservoir storage. When upstream reservoir storage is high, allocations and San Luis fill targets are increased. During a prolonged drought when upstream storage is low, allocations and fill targets are correspondingly low.

### **Delta**

The State Water Resources Control Board (SWRCB) specifies water quality standards for the Delta. Currently the CVP and SWP share the obligation to meet these standards as defined by the Coordinated Operation Agreement. Salinity standards must be translated into flow equivalents to be modeled in CalSim-II. However flow-salinity relationships in the Delta are non-linear.

CalSim-II uses DWR's Artificial Neural Network (ANN) model to simulate the flow-salinity relationships for the Delta by estimating the salinity at water quality stations in the Delta. The ANN model correlates DWR's Delta Simulation Model (DSM2) model-generated salinity at key locations in the Delta with Delta inflows, Delta exports, and Delta Cross Channel operations by estimating electrical conductivity at the following four locations for the purpose of modeling Delta water quality standards: Old River at Rock Slough, San Joaquin River at Jersey Point, Sacramento River at Emmaton, and Sacramento River at Collinsville. In its estimates, the ANN model considers antecedent conditions up to 148 days, and considers a "carriage-water" type of effect associated with Delta exports.

CalSim-II passes antecedent (previous month) flow conditions and known (or estimated) current month flows to an ANN dynamic link library (DLL). The DLL returns coefficients for a linear constraint that binds Sacramento River Delta inflows to Delta exports based on a piecewise linear approximation of the flow-salinity relationship.

### **Surface Water/Groundwater Interaction**

Groundwater has only a limited representation in CalSim-II. Modeling groundwater in CalSim-II has evolved from the simpler Depletion Analysis approach to the current multiple-cell approach used in the Sacramento Valley. Within the Sacramento Valley floor, groundwater is explicitly modeled in CalSim-II using a multiple-cell approach based on depletion study area boundaries. There are a total of 12 groundwater cells. Stream-aquifer interaction, groundwater pumping, recharge from irrigation and sub-surface flow between groundwater cells are calculated dynamically. All other groundwater flow components are preprocessed and represented in CalSim-II as a fixed time series. In areas of high groundwater, CalSim-II calculates groundwater inflow to the stream as a function of the groundwater head and stream stage. In areas of low groundwater elevation where the groundwater table lies below the streambed, CalSim-II assumes a hydraulic disconnect between the stream and aquifer. In this case seepage is only a function of stream stage.

## **Regulatory Conditions**

### **Water Rights**

The SWRCB Water Quality Control Plan (WQCP) and other applicable water rights decisions, as well as other agreements are important factors in determining the operations of both the Central Valley Project (CVP) and the State Water Project (SWP).

Historically, approximately 90 percent of the CVP water has been delivered to agricultural users, including prior water rights holders. Total annual contracts exceed 9 million acre-feet per year, including over 1 million acre-feet per year of Friant Division Class II supply, which is generally available only in wet years. The CVP also delivers water from the San Joaquin River to CVP contractors and water right holders located along the Madera and Friant Kern canals. Water from New Melones Reservoir is used by water rights holders in the Stanislaus River watershed and CVP contractors located in the northern San Joaquin Valley. In addition, water is conveyed via the Sacramento and American rivers to CVP contractors, water rights holders along the Sacramento and American rivers.

The SWP delivers water to water rights holders in the Feather River Service Area (FRSA) prior to meeting its other contracts. The contract entitlement in CalSim-II for the FRSA water rights holders downstream of Lake Oroville is 948 taf/yr in non-drought years, this can drop to 630 taf/yr when deficiencies of up to 50 percent are imposed in “drought” years on some parts of the contract amount. The historical 24-year average annual SWP deliveries to the FRSA including the senior water rights holders downstream of Lake Oroville are 840 taf/yr. CalSim-II represents this by imposing 50 percent deficiencies in 1977, 1988 and 1991. In non-drought years the land use-based demand is usually significantly less than the contract entitlement.



## Water Service Contracts and Deliveries

The CVP has 253 water service contracts consisting of settlement contracts, agricultural water service contracts, urban water service contracts, and refuge requirements. CVP contracts south of the Delta consist of exchange contracts, agricultural service contracts, and M&I service contracts.

The SWP has 29 long-term contracts for water supply totaling about 4.2 million acre-feet annually, of which about 4.1 million acre-feet are for contracting agencies with service areas south of the Sacramento-San Joaquin Delta. About 70 percent of this amount is the contract entitlement for urban users and the remaining 30 percent for agricultural users. CalSim-II allocations are set per the Monterey Agreement criteria, which imposes any deficiencies equally between agricultural and M&I requests as a percentage. PDF Attachments D-1 and D-2, provide tables showing CVP and SWP contract amounts for Study 7.0 and Study 8.0 respectively. Study 7.1 assumptions are the same as Study 7.0 with the exception of Freeport Regional Water Project demands.

## Coordinated Operations Agreement (COA)

The COA is both an operations agreement and a water rights settlement defined by the SWRCB Decision 1485. Decision 1485 ordered the CVP and SWP to guarantee certain conditions for water quality protection for agricultural, M&I, and fish and wildlife use.

The purpose of the COA is to ensure that the CVP and the SWP each obtains its share of water from the Delta and bears its share of obligations to protect the other beneficial uses of water in the Delta and Sacramento Valley. Coordinated operation by agreed-on criteria can increase the efficiency of both the CVP and the SWP.

COA Sharing Formulas are used as constraints in the LP formulation within the model. These formulas or constraints ensure that the COA is maintained in the model. CalSim-II uses mixed integer programming to determine in which of the two possible conditions the model is operating under for the given month: Balanced Water Conditions or Excess Water Conditions.

## CVPIA 3406(b)(2) Operations

According to the 1992 Central Valley Project Improvement Act (CVPIA), the CVP must “dedicate and manage annually 800,000 acre-feet of Central Valley Project yield for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by this title; to assist the State of California in its efforts to protect the waters of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; and to help to meet such obligations as may be legally imposed upon the Central Valley Project under State or Federal law following the date of enactment of this title, including but not limited to additional obligations under the Federal Endangered Species Act.” This dedicated and managed water, or (b)(2) water as it is called, is water that the U.S. Fish and Wildlife Service (FWS), in consultation with Reclamation and other agencies, has at its disposal to use to meet the primary restoration purposes of CVPIA 3406(b)(2), the CVP’s WQCP obligations and any legal requirements imposed on the CVP after

1992. CVPIA 3406 (b)(2) water may be managed to augment river flows and also to curtail pumping in the Delta to supplement the WQCP requirements.

To simulate the 3406 (b)(2) accounting, the model uses metrics calculated in the (b)(2) simulation step. The metrics measure the flow increases and export decreases from D1485 to D1641 WQCP Costs, and from D1485 to (b)(2), total (b)(2) costs. The following assumptions were used to model the May 2003 3406 (b)(2) Department of the Interior decision.

1. **Allocation of (b)(2) water** is 800,000 acre-feet per year (af/yr), 700,000 af/yr in 40-30-30 Dry Years, and 600,000 af/yr in 40-30-30 Critical years.
2. **Upstream flow metrics** are calculated at Clear Creek, Keswick, Nimbus, and Goodwin Reservoirs where (b)(2) water can be used to increase flow for fishery purposes. For OCAP BA modeling purposes, CVPIA (b)(2) accounting of Goodwin releases and volumes are independently determined based on Stanislaus River water availability and New Melones water allocation estimates. The assumptions used in CalSim-II for taking an upstream action at one of the previously mentioned reservoirs are:
  - **October-January**
    - Clear Creek Releases: Action is on if Trinity Beginning of Month Storage >600,000 af.
    - Keswick Releases: Action is on if Shasta Beginning-of-Month Storage > 1,900,000 af.
    - Nimbus Releases: Action is on if Folsom Beginning-of-Month Storage > 300,000 af.
    - For all releases, if the 200,000-af target is projected to be violated the model will try to reduce the magnitude of the actions in December and/or January.
  - **February-September**
    - Clear Creek Releases: Action is on if Trinity Beginning-of-Month Storage >600,000 af.
    - Keswick Releases: Action is on if Shasta Beginning-of-Month Storage > 1,900,000 af and if remaining (b)(2) account > projected coming WQCP costs.
    - Nimbus Releases: Action is on if Folsom Beginning-of-Month Storage > 300,000 af and if remaining (b)(2) account > projected coming WQCP costs.
3. **The export metric** is the change in total CVP pumping (Jones + CVP Banks) from the base case (D1485). Assumptions used in CalSim-II for taking a delta action are:
  - Winter Actions (December through February) and Pre-Vernalis Adaptive Management Plan (VAMP) (April Shoulder) actions are off.
  - VAMP Actions: Always taken and done at a 2:1 (Vernalis flow to CVP pumping ratio) ratio if non-VAMP Vernalis flows are greater than 8,600 cubic feet per second (cfs).

- **May Shoulder:** Action turned on if the remaining (b)(2) is greater than or equal to the discounted remaining WQCP cost + anticipated Clear Creek cost (25,000 af).  
DISCOUNT = If the annual WQCP cost > 500,000 af, the difference is subtracted from the remaining WQCP cost.
- **June Ramping:** Action turned on if the remaining (b)(2) is greater than or equal to the discounted remaining WQCP cost + anticipated Clear Creek cost (20,000 af).
- Both May Shoulder and June Ramping are further restricted to stay within the remaining (b)(2)account – remaining WQCP costs.

## Joint Point of Diversion

Joint Point of Diversion (JPOD) is used to describe the ability of SWP to wheel water for the CVP through Banks Pumping Plant when unused capacity exists. In theory, the term is also used for the wheeling of SWP water through CVP facilities, but due to the capacity limitations on Jones Pumping Plant it is rare to find this direction of wheeling. JPOD is available to the CVP under (1) surplus conditions when the SWP has filled San Luis and satisfied it's Article 21 demand and under (2) balanced conditions when the SWP has satisfied it's target storage in San Luis and no longer wishes to move Oroville water to San Luis. SWP wheeling for the CVP Cross-Valley Canal users is simulated in all simulations under these conditions. Additional CVP use of Banks Pumping Plant (JPOD) is currently only modeled in the JPOD and EWA simulations.

## D-1641 Operations

The December 1994 Accord committed the CVP and SWP to a set of Delta habitat protective objectives that were incorporated into the 1995 WQCP and later, along with the Vernalis Adaptive Management Program (VAMP), were implemented by D-1641. The actions the CVP and SWP take in implementing D-1641 significantly reduced the export water supply of both projects. Significant elements in the D-1641 standards include X2 standards, export/inflow (E/I) ratios, real-time Delta Cross Channel operation, San Joaquin flow standards. A discussion of the X2 implementaion is presented in Attachment 3.

## Minimum Flow for Navigation – Wilkins Slough

Historical commerce on the Sacramento River resulted in the requirement to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation. There is currently no commercial traffic between Sacramento and Chico Landing, and Corps has not dredged this reach to preserve channel depths since 1972. However, long-time water users diverting from the river have set their pump intakes just below this level. Therefore, the CVP is operated to meet the navigation flow requirement of 5,000 cfs to Wilkins Slough (gauging station on the Sacramento River) under all but the most critical water supply conditions to facilitate pumping.

## **SWRCB Water Rights Order 90-05 and Water Rights Order 91-01**

In 1990 and 1991, SWRCB issued Water Rights Orders 90-05 and 91-01 modifying Reclamation's water rights for the Sacramento River. The orders included a narrative water temperature objective for the Sacramento River and stated that Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Powerplant to meet a daily average water temperature of 56°F at RBDD in the Sacramento River during periods when higher temperatures would be harmful to fisheries.

Under the orders, the water temperature compliance point may be modified when the objective cannot be met at RBDD. In addition, Order 90-05 modified the minimum flow requirements initially established in the 1960 MOA for the Sacramento River below Keswick Dam.

### **Flood Control**

Flood control objectives for Shasta Lake require that releases be restricted to quantities that will not cause downstream flows or stages to exceed specified levels. These include a flow of 79,000 cfs at the tailwater of Keswick Dam, and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station, which corresponds to a flow of approximately 100,000 cfs. Maximum flood space reservation is 1.3 million acre-feet, with variable storage space requirements based on an inflow parameter.

Storage in Lake Oroville must be lowered every year to make room for the winter rains and spring snowmelt that could cause flooding. Monthly flood control space requirements are provided by the U. S. Army Corps of Engineers for flood control operation of Lake Oroville. In all but four months (May, June, July, and August) flood control space is provided based on antecedent precipitation and ground wetness conditions.

Flood control requirements and regulating criteria are specified by Corps and described in the Folsom Dam and Lake, American River, California Water Control Manual (Corps, 1987). Flood control objectives for Folsom require that the dam and lake are operated to: (1) reduce flooding along the lower Sacramento River and in the Delta in conjunction with other CVP projects; (2) Provide the maximum amount of water conservation storage without impairing the flood control functions of the reservoir; and (3) Provide the maximum amount of power practicable and be consistent with required flood control operations and the conservation functions of the reservoir.

If the inflow into Folsom Reservoir causes the storage to encroach into the space reserved for flood control, releases from Nimbus Dam are increased. Due to operation strains and to provide additional protection, on 1996 Reclamation operated according to modified flood control criteria, which reserve 400,000 to 670,000 acre-feet of flood control space in Folsom and a combination of upstream reservoirs.

New Melones Reservoir flood control operation is coordinated with the operation of Tulloch Reservoir. The flood control objective is to maintain flood flows at the Orange Blossom Bridge at less than 8,000 cfs. When possible, however, releases from Tulloch Dam are maintained at levels that would not result in downstream flows in excess of 1,250 cfs to 1,500 cfs because of seepage problems associated with flows above this level. Up to 450,000 acre-feet of the 2.4 million acre-foot storage volume in New Melones Reservoir is dedicated for flood control and 10,000 acre-feet of Tulloch Reservoir storage is set aside for flood control.

## SWP Monterey Agreement

The 1994 Monterey Agreement revised the water management strategy of the SWP and its contractors and eventually led to SWP contract amendments. The Monterey Agreement changed the allocation procedure of SWP deliveries so that cuts would be made proportionally to all SWP contractors, authorized the transfer of 130,000 acre-feet of agricultural contract amounts to M&I contractors, aggregated several contractual obligations for water delivery into one water type (Article 21), and resulted in KCWA assumption of the Kern Water Bank.

## Environmental Water Account

Three management agencies (FWS, National Oceanic and Atmospheric Administration Fisheries [NMFS], and California Department of Fish and Game [DFG]) and two project agencies (Reclamation and DWR) share responsibility for implementing and managing the Environmental Water Account (EWA). The management agencies manage the EWA assets and exercise the biological judgment to recommend operational changes in the CVP and SWP that are beneficial to the Bay-Delta system. Together, the management and project agencies form an EWA Team, or EWAT.

CalSim-II EWA is meant to illustrate a *representative* rather than prescriptive imposition of EWA on projects' operations. CalSim-II's EWA representation only approximates actual EWA operations. One difference is the time step difference between CalSim-II decisions and actual EWA decisions. Actual EWA operating decisions (especially actions) may apply to multi-day or multi-week periods. In contrast, EWA decisions in CalSim-II are made monthly. Another difference is the basis of initiating EWA actions (i.e. export reductions). In CalSim-II, the absence of simulated biological conditions forces monthly action decisions to be responsive to simulated hydrologic conditions and monthly rules. Actual EWA decisions on actions are cognizant of recent monitoring of system hydrological and biological conditions.

The objective of simulating EWA for OCAP modeling is to represent the functionality of the program in two ways: as it has been implemented by EWAT during WY2001-2007, referred to as Full EWA and as it is foreseen to be implemented in a limited capacity in coming years by CALFED Operations, referred to as Limited EWA. The simulation of EWA in CalSim-II, involves representation of the following fundamental aspects of the EWA program:

- Implementation of EWA actions at project export facilities to protect/restore fisheries,
- Acquiring assets to mitigate action impacts on deliveries,
- Assessment of how action impacts are affecting project deliveries and storage (i.e. causing debt), and
- Application of acquired assets to manage debt.

EWA actions are simulated as SWP/CVP export changes, experienced as either a pumping *reduction* (i.e. monthly reduction in pumping volume relative to a baseline level) or a pumping *restriction* (i.e. reduction of pumping down to a target pumping level, regardless of baseline

level). The action strategy for the Full EWA representation includes six specific actions, while the Limited EWA includes one or two.

The following assumptions are designed for monthly simulation and do not equate to a collection of EWA actions that will be needed in any specific future year. Their complexity represents the extent of export-related fish actions that can be rationalized and simulated in CalSim-II. They are to be interpreted as monthly surrogates for an assumed set of potential fish actions expected to occur on daily to weekly time scales. Development of these assumptions was steered in 2006 in discussions with EWA operations staff from CA Department of Fish and Game, U.S. Fish & Wildlife Service, and NOAA Fisheries.

### **1. Winter Reductions 1 (December – February):**

- Do Action if:
  - it's December or January; or,
  - it's February and the hydrologic year-type is assessed to be Above Normal or Wet according to the Sac 40-30-30 Index.
- Action is:
  - a *reduction* in total Delta exports, equal to 50 TAF in the action month, allocated evenly to total SWP and CVP exports.
- Rationale:
  - The intent of Winter Reductions 1 to represent a “seasonal” amount of expected export cuts, and to distribute the cuts among Winter months. Actual EWA operations (i.e. from 2001 to present) have involved implementing multi-day rather than monthly export restrictions during Winter months.

### **2. Winter Reductions 2 (February – March):**

- Do action if:
  - it's February or March,
  - “previous summer stress” conditions are met (see Rationale)
  - “winter delta mitigating conditions” are not met (see Rationale)
- Action is:
  - a *reduction* in total Delta exports, equal to either 50, 75, or 100 TAF in the action month, allocated evenly to total SWP and CVP exports.
- Rationale:
  - It was reasoned that the distribution of winter months' actions under Winter Reductions 1 was reasonable, but that in some drier February and March months, the EWA management agencies would also be inclined to reduce export to assist emigrating Winter-Run Chinook, Spring-Run Chinook, and Steelhead

populations. The conditions for this action would be based on whether the populations had been stressed during previous summers in upstream tributaries (“previous summer stress”), and also on whether the delta exhibited high flows or low exports during the Feb/Mar emigration period (“delta mitigating conditions”).

- “Previous summer stress” was defined as a function of river temperatures during the previous summer’s spawning and incubation season (i.e. July-September). Water temperature greater than 56 Fahrenheit (F) during this period are assumed to adversely affect reproductive success. An assumption was made that spawning vulnerability in the basin could be indicated by simulated monthly temperature conditions on the Sacramento River at Balls Ferry. A table of “Previous summer stress” classifications was developed (Table 2), where classifications ranging from A to C represent relative levels of higher to lower concern. To implement these assumptions in CalSim-II and determine the triggering of Winter Reductions 2, an annual time series of concern classifications was developed as input to the simulation. This time series was based on simulated Sacramento River temperature at Balls Ferry from the OCAP Future B2 study (OCAP BA, 2004).

**Table 2. “Previous Summer Stress” Classifications for Winter Reductions 2**

**If “Simulated Water Temperature at Ball’s Ferry” exceeds “X” (degrees F), then Level of Concern =:**

Month	X <= 56	X = 57	X = 58	X = 59	X = 60+
July	--	A	A	A	A
August	--	B	B	A	A
September	--	C	C	B	A

- Given concern levels A, B, or C, corresponding monthly amounts of export reduction were assumed (i.e. 100, 75, 50 TAF/month, respectively, during February and/or March). However, it was assumed that favorable delta conditions during emigration would eliminate the need for action (i.e. “delta mitigating conditions”), regardless of previous summer stress. Two mitigating conditions were assumed to override the need for action: if exports were already relatively low (e.g. <4000 cfs combined), or if Delta inflows were already relatively high (e.g. Freeport >40,000 cfs or total Delta inflow > 50,000 cfs).
- Simulation results show that Winter Reductions 2 compliments Winter Reductions 1 as the occurrence of Winter Reductions 2 is generally during drier February and March months. February occurrence of Winter Reductions 1 is during Wet and Above Normal years only

**3. VAMP Export Restriction (April 15 – May 15):**

- Do Action if:
  - it's April or May.
- Action is:
  - a *restriction* on total Delta exports to a target level during the VAMP-period, where the target depends on San Joaquin River flow conditions. Action applies only to SWP exports because CVP exports are already restricted to the same target level through the B2 action strategy included in the baseline operation relative to EWA.
- Rationale:
  - Historical EWA operations (i.e. from 2001 to present) have involved implementing this VAMP-period restriction.

**4. VAMP April-Shoulder Export Restriction (April 1 – April 14):**

- Do Action if:
  - it's April
  - the hydrologic year-type is assessed to be Dry or Critical according to the Sac 40-30-30 Index
  - foreseeable October debt at San Luis does not exceed 100 TAF, considering forecasted asset acquisitions April through September.
- Action is:
  - an extension of the VAMP-period export restriction into the April 1-14 period. SWP export is constrained to the target level. CVP exports are similarly restricted unless they were already constrained by the analogous B2 "Pre-VAMP" action.
- Rationale:
  - During preparation of the Long-Term EWA studies, the EWA management agencies expressed interest to simulate VAMP April Shoulder as a priority action. Recognizing that an EWA action-asset balance must be maintained, the logic predicating the action on a tolerable level of foreseeable October debt was developed. When determining foreseeable October debt on April 1<sup>st</sup>, it is assumed that VAMP Export Restriction is implemented.

**5. VAMP May-Shoulder Export Restriction (May 16 – May 31):**

- Do Action if:
  - it's May



- foreseeable October debt at San Luis does not exceed 100 TAF, compensating for forecast asset acquisitions May through September
- Action is:
  - an extension of the VAMP-period export restriction into the May 16-31 period. SWP export is constrained to the target level. CVP exports are similarly restricted unless they were already constrained by the analogous B2 “Post-VAMP” action.
- Rationale:
  - The EWA management agencies indicated a preference to implement the “May Shoulder” extension of the VAMP restriction in all years. Recognizing that an EWA action-asset balance must be maintained, the logic predicating the action on a tolerable level of foreseeable October debt was developed. When determining foreseeable October debt on May 1<sup>st</sup>, it is assumed that VAMP Export Restriction is implemented.

## 6. June Ramping:

- Do Action if:
  - it’s June
  - the Post-VAMP action was implemented in the preceding month.
  - foreseeable October debt at San Luis does not exceed 50 TAF, given assumed asset acquisitions from May through September.
- Action is:
  - A split-month export restriction where total exports from June 1-7 are set equal to the VAMP target level, and total exports from June 8-30 are allowed to be as high as what’s allowed by the June E/I ratio (i.e. ratio of ”allowable exports”-to-“Delta inflow”). The restricted amount is divided evenly between SWP and CVP. However, CVP is constrained by its half share or 3000 cfs, whichever is less, and only if B2-June Ramping was not already implemented in the baseline operation.
- Rationale:
  - The EWA management agencies suggested that there may be an interest in implementing this action during any year when “May Shoulder” was implemented. The action is meant to promote gradual changes to Delta hydrologic conditions near the export facilities, transitioning from VAMP-constrained export levels (i.e. May Shoulder) to elevated export conditions constrained by other non-EWA Delta requirements. In recognition of the importance of an asset/action balance, it was proposed the action be predicated on a tolerable level of “foreseeable October debt”.

The action strategy for the Limited EWA includes adaptations of the VAMP and Post-VAMP actions. Both are considered in the context of expected asset acquisition. No other actions are taken.

#### 7. VAMP Export Restriction (April 15 – May 15):

- Do Action if:
  - it's April or May.
- Action is:
  - a *restriction* on total Delta exports to a target level during the VAMP-period, where the target depends on San Joaquin River flow conditions. Action applies only to SWP exports because CVP exports are already restricted to the same target level through the B2 action strategy included in the baseline operation relative to EWA.
  - potentially limited by the expected acquisition of purchased asset. If the expected purchase will not cover an export restriction to the full VAMP target level, the restriction is relaxed to whatever level can be supported by the expected purchase.
- Rationale:
  - Department of Water Resources guidelines on intended actions.

#### 8. Post-VAMP Export Restriction (May 16-31):

- Do Action if:
  - it's May
  - expected acquisition of purchased asset was enough to cover the full VAMP period restriction for SWP exports, and there is additional asset remaining to support further export restrictions.
- Action is:
  - an extension of the VAMP-period export restriction of SWP exports into the May 16-31 period, up to the level supportable by assets remaining after the VAMP period action. CVP export restrictions are not increased beyond whatever level was achieved through the Post-VAMP action under B2.
- Rationale:
  - Department of Water Resources guidelines on intended actions.

Impacts of EWA actions on storage and delivery are defined as EWA debt. Measurement of debt is performed during simulation by comparing EWA-step project deliveries and storage conditions to regulatory baseline conditions. Debt is not limited during simulation. Instead, debt is a simulated “relief valve” indicating the balance between input strategies for action, asset-acquisition, and asset-application to reduce debt. Debt should occur due to EWA actions, but it

should also be managed using assets so that there is no harm to project deliveries. There should be sufficient assets given the assumed set of actions.

Occurrence of SOD delivery debt triggers immediate payback using any available assets. Failure to address this type of debt in modeling would indicate that EWA program assets are not in balance with the assumed actions. Debt to San Luis storage should generally be managed within each water year, but carryover debt between water years is permitted in the representation of the Full EWA with the program structure encouraging that these carryover amounts at San Luis do not exceed 100 TAF. Under the Limited EWA representation, carryover debt is unlikely due to the deliberate asset/action balance.

EWA assets are water purchases or operational opportunities. One key aspect of assets management involves conveyance of assets from Upstream of Delta (i.e. North-of-Delta, NOD) sources to the Export Service Area (i.e. South-of-Delta area, SOD). This conveyance can involve asset losses associated with cross-delta conveyance (i.e. carriage water costs).

The seasons of EWA asset acquisition and EWA export actions are not coincidental. Moreover, the target amount of purchase acquisitions varies less from year to year compared to the “water costs” of EWA export actions. This creates a need for collection and storage of EWA assets until they are needed. A key storage resource is San Luis, where EWA is allowed to store assets on top of CVP or SWP storage. This lower storage priority puts EWA assets stored in San Luis at risk to be lost to CVP/SWP when the projects operate to fill San Luis.

Other storage resources available to EWA are in upstream-of-Delta reservoirs, depending on criteria conditions for “backing-up” assets into these reservoirs. As with San Luis, EWA assets in upstream-of-Delta reservoirs are stored on top of conservation storage, and are the first amounts of stored water to be spilled when the reservoirs fill to flood-control space requirements. These “backed-up” assets are created when either (a) an EWA Spring action causes export reductions and corresponding upstream release reductions, or (b) an EWA NOD purchase is allowed to exchange with an upstream reservoir release (as permitted by SWP and CVP) given that the purchase cannot be conveyed through Banks during the month of purchase. The first mechanism is simulated to only occur in association with Spring EWA actions because it is reasoned that actual Spring actions would persist for several weeks and could reasonably cause a release reduction. In contrast, actual Winter actions are likely to occur during multi-day periods, and CVP/SWP operators have indicated that they would not adjust upstream release rates for such short periods. Thus, creation of backed-up assets in association with simulated Winter EWA actions is not permitted in the modeling.

## **Asset Acquisitions – Water Purchases:**

Modeling of water purchases occurs in three steps: **Step 1** total annual purchase targetting, **Step 2** definition of NOD/SOD split, and **Step 3** identification of NOD and SOD purchase sources.

### **1. Step 1: Define Total Annual Purchase Target.**

Modeling of the Full EWA assumes that the annual purchase target varies by hydrologic year-type (Table 3). Annual purchase targets are updated in May and apply to a May-April purchase year.

**Table 3. EWA Annual Purchase Target**

<b>Sacramento 40-30-30 Index</b>	<b>Total Purchase Target (TAF)</b>
Wet	250
Above Normal	250
Below Normal	250
Dry	230
Critical	210

## 2. Step 2: Define NOD Share of Total Annual Purchase Target.

Water purchases can be made from either NOD or SOD sources. From a financial perspective, it is desirable to maximize NOD purchases since they cost less than SOD counterparts, even with conveyance losses. From the perspective of disclosing potential environmental effects, it is also assumed that maximizing NOD purchases is desirable for the sake of showing exhausted cross-Delta conveyance capacity and depicting maximized Delta effects associated with asset conveyance. However, it is recognized that conveyance limitations in wetter years (or higher delivery allocation years) will limit capture of NOD target purchase, which may create unacceptable SOD debt conditions. For modeling purposes, the NOD share of total purchase target is assumed to decrease in wetter years, indicated by SWP allocation to agricultural contractors (Table 4).

**Table 4. NOD Share of EWA Annual Purchase Target**

<b>SWP Ag. Allocation (%)</b>	<b>NOD Share (%) of Annual Purchase-Target</b>
0	90
10	90
20	90
30	90
40	85
50	85
60	75
70	70
80	60
90	60
100	50

It is understood that some NOD purchases will be lost to Delta outflow during conveyance operation due to carriage water costs. To meet the total purchase target as a capture goal, the simulated NOD share volume is inflated by an anticipated amount of average annual carriage water loss, defined as 20% of NOD share volume. Simulated carriage water losses can be higher or lower than this anticipated value.

Two additional target decisions are made. The first is May addition to the NOD purchase target, representing “put” purchases as part of the Wet-Year/Dry-Year Exchange, discussed later in this section. The second is a June supplement to SOD purchase target responding to perceived supplemental asset need given April and May forecasts of carryover debt and decisions on whether to implement April Shoulder and May Shoulder. This SOD purchase supplement is triggered under either of two cases:

- Doing April Shoulder or May Shoulder without supplement results in a debt forecast between 50 and 100 TAF.
- The debt forecast exceeds 100 TAF even without doing April Shoulder or May Shoulder.

Noting that the simulated debt-forecast is uncertain in April and May and sometimes underestimates the carryover debt result, the SOD purchase supplement is sized to reduce the debt forecast to 50 TAF.

### **3. Step 3: Allocate NOD and SOD shares to Purchase Sources.**

OCAP modeling used the range of EWA purchase options that was developed for the Common Assumptions Common Model Package. Annual purchase limitations can depend on regulatory baseline operations for higher priority water contractor transfers that also use some of the same sources for water supply. The purchase sources are:

#### **North of Delta**

- Yuba Basin Transfer – defined by results of Yuba Accord analysis
- Sacramento and Feather basin groundwater substitution (DSAs 69, 12, and 15) – up to 200 taf/yr, limited to 150 taf in consecutive dry years
- Sacramento and Feather basin crop idling (DSAs 69, 12, and 15)

#### **South of Delta**

- DMC Exchange Contractor groundwater substitution
- DMC Exchange Contractor crop idling
- California Aqueduct groundwater substitution
- California Aqueduct crop idling
- Dry/Wet Exchange calls

The representation of Full EWA actions used access to all of the above purchase assets. The Limited EWA representation used only the NOD Yuba Basin Transfer as a source of purchased water.

## Asset Acquisitions – Operational:

The OCAP modeling has the capability to represent the following specific operational assets:

1. **Source Shift due to Low Level of San Luis** – This asset is used when San Luis storage falls below 300 TAF due to the presence of high EWA storage debt, thereby threatening water quality conditions in the reservoir. High EWA storage debt is defined to be 100 TAF. When these conditions are met, a source shift of 25 TAF is implemented with Metropolitan Water District (MWD). Delivery is reduced at three MWD diversion locations on the west and east branches. The purchase amount is transferred from SWP San Luis to EWA San Luis. There is no limit on the buildup of the source shift “account”. Payback from EWA to specific MWD locations occurs when EWA has sufficient assets to support payback and when San Luis storage exceeds 300 TAF.
2. **Semitropic Groundwater Bank** – This asset is used when there is potential for SWP/CVP takeover of EWA assets stored in San Luis. This situation occurs during months when SWP/CVP filling of San Luis is likely to encroach on EWA-occupied space in San Luis. Given this situation, EWA removes EWA assets from San Luis and “puts” them at Semitropic. “Puts” are modeled as additional delivery at Semitropic’s location in the Tulare Basin. These assets are then retrieved, or “called”, when San Luis debt conditions become severe. “Calls” are modeled as delivery reductions at the Semitropic locations.
3. **500 cfs July-Sep Capacity at Banks** – This conveyance asset enables EWA wheeling of assets from NOD to SOD locations. The SWP is currently limited to 6680 cfs diversion rate into Clifton Court forebay. Permission has been granted by the U.S. Army Corps of Engineers to increase this diversion limit by 500 cfs during the months of July, August, and September, solely for pumping by the EWA.
4. **50% of JPOD Capacity Assessed at Banks** – The SWP will use excess capacity at Banks Pumping Plant to wheel water for the CVP and EWA. This excess capacity is assessed under terms of Joint Point of Diversion (JPOD). This excess capacity is to be shared between CVP and EWA on a 50/50 basis.
5. **50% of B2 releases pumped by SWP** – The EWA receives a 50% share of the water gained from CVPIA (b)(2) or Environmental Restoration Program (ERP) upstream releases by SWP through use of their Delta export facilities. The value of this EWA asset varies with the amount of (b)(2) releases in the current year and the SWP’s excess capacity to export additional water.
6. **Carried-over debt “spill” at EWA San Luis** - Carried-over SOD storage debt is simulated to be managed through either: (1) direct dedication of assets, or (2) debt spilling. Dedication of assets involves transferring the accumulated purchases and variable assets from EWA San Luis into the projects’ shares of San Luis to repay impacts caused by this year’s actions and/or carried-over impacts from last year. The second tool,

debt spilling, involves elimination of carried-over SOD debt through the pumping of surplus water into the debt space under baseline regulatory conditions. Spill of carryover debt to SWP can be done under the following specific conditions:

- There was remaining capacity at Banks
  - There was surplus water in the Delta that could have been exported
  - The sum of end-of-month debt and stored water at SWP San Luis exceeded the sum of storage capacity and the “Article 21 deficit” (an Article 21 deficit represents demand minus what was delivered)
7. **Backed-Up water from Spring EWA Actions** - This variable asset emerges in NOD reservoirs when EWA actions to restrict exports during Spring are coincident with NOD reservoir-release reductions. Coincidental release reductions are not permitted unless the Delta is simulated to be “in balance” (i.e. assessed during simulation as the joint occurrence of “No Delta Surplus” and “In Basin Use” conditions controlling CVP-SWP coordinated operations). Given a release reduction, EWA gains control of this upstream storage increase. Release reductions are measured below Keswick, Thermolito, and Nimbus. Reductions at Keswick represent collective back-up at Trinity Reservoir and Lake Shasta, but the backed-up water is situated at Lake Shasta.

The following Operational Asset was not modeled:

8. **E/I Relaxation** – Under SWRCB Decision 1641 (D1641), there is a restriction on project exports that varies throughout the year as a percentage of Delta inflow (usually 35 percent or 65 percent). This restriction is often referred to as the E/I limit on exports. However, D1641 allows for the E/I limit to be relaxed upon meeting certain requirements. It has been proposed that EWA be allowed to use this flexibility to augment its ability to export Delta Surplus flows with its JPOD capacity and wheel NOD assets to EWA San Luis. The ability to relax the E/I limit varies with daily hydrologic and biological conditions in the Delta. CalSim-II, being a monthly model, is unable to capture the daily subtleties required to simulate E/I relaxation.

OCAP modeling of the Full EWA included all of the above operational assets except for E/I relaxation. Modeling of the Limited EWA operation also excluded source shifting and the semitropic water bank.

### **Asset Conveyance:**

As mentioned, EWA has access to Banks conveyance capacity on an intermittent basis through JPOD and on a dedicated basis during July-September. The priority of EWA asset wheeling through Banks is:

1. Delta Surplus,
2. NOD Purchases without interim storage

3. Interannual DryWet Exchange Puts
4. NOD backed-up assets.

Exercise of this access and operating to convey assets can sometimes involve losing a portion of the NOD asset to delta outflow as carriage water associated with export. Asset conveyance is permitted to occur with carriage water losses permitted up to 35 percent, and encouraged to remain below 20 percent.

## Model Mathematics

CalSim-II represents California's water resources system as an interlinked network of nodes and arcs. CalSim-II routes water through the arcs according to a set of user-defined priorities. CalSim-II utilizes optimization techniques to route water through a network. A linear programming (LP)/mixed integer linear programming (MILP) solver determines an optimal set of decisions for each time period given a set of weights and system constraints (DWR 2002). The physical description of the system is expressed through a user interface with tables outlining the system characteristics. The priority weights and basic constraints are also entered in the system tables. The programming language used, Water Resources Engineering Simulation Language (WRESL), serves as an interface between the user and the LP/MILP solver, time-series database, and relational database.

## Documentation

There are many sources of information documenting the CalSim-II Model. Since the release of the June 30, 2004 OCAP BA, a peer review response and several studies have been conducted regarding CalSim-II. The relevant reports include:

1. An external peer review commissioned by the California Bay-Delta Authority (CALFED); (Close A., Haneman et al, 2003)
2. An analysis of an historical operations simulation; (DWR, 2003b)
3. An analysis of the effect varying selected parameters has upon model results (sensitivity analysis study); (DWR 2005)
4. An analysis of the significance of the simulation time-step to the estimated SWP delivery amounts (DWR 2005).
5. Peer review of San Joaquin River Valley application (Ford et al, 2006)
6. CALFED Common Model Package (CALFED, 2005)

The pertinent information from these reports is included in the following sections on model selection rationale, reliability and acceptability of approach, quality assurance, and assumptions/limitations.



## Rationale

The OCAP process requires the application of the best available science and engineering to the analysis of water management objectives for the CVP and SWP. The OCAP effort requires the use of a system wide CVP/SWP operations planning model and CalSim-II currently serves that purpose. CalSim-II is the system model for any inter-regional or statewide analysis of water in the Central Valley of California. CalSim-II has important strengths as a systems operations planning model, particularly compared with available alternatives and its predecessors. The primary strengths include:

1. Coordination of Federal and State Interests is unique aspect of CalSim-II which allows a high degree of cooperation between Federal (i.e., U.S. Bureau of Reclamation) and State (i.e. California Department of Water Resources) interests in its development. This kind of cooperation is rare, and in fact this may be the only such example of such coordination for a system of this scale and complexity. This includes a common schematic, hydrologic representation of the system, common set of facility capacities, and common representation of system operating policies.
2. CalSim-II is a data-driven simulation model with an optimization engine. This modeling approach provides: a) much greater flexibility than its predecessors and traditional water resources simulation approaches, and b) a promising framework for improving transparency, data, and model documentation, compared to other approaches.
3. The model and data are substantially in the public domain, facilitating transparency and adaptability for California's decentralized water system.
4. Model improvements have been steadily pursued since the adoption of CalSim-II as the CVP/SWP operations planning model.

## Reliability and Acceptability of Approach

As noted above, a number of peer review efforts have been conducted to evaluate the applicability of CalSim-II to the CVP/SWP system and California water management. These peer reviews include the following:

1. The CALFED Science Program invited Dr. Pete Loucks of Cornell University to organize and chair an expert panel for the review of CalSim-II Water Resources Planning Model. In addition to Dr. Loucks as the chairperson, the panel consisted of Drs. A. Close (Murray Darling Basin Commission), W.M. Haneman (University of California, Berkeley), J.W. Labadie (Colorado State University), J.R. Lund (University of California, Davis), D.C. McKinney (University of Texas, Austin), and J.R. Stedinger (Cornell University). The panel published its final report on December 4, 2003, titled: A Strategic Review of CalSim-II and its Use for Water Planning, Management, and Operations in Central California.
2. In response to the short-term and long-term improvements recommended in the December 4, 2003 CalSim-II Panel Review Report, DWR and Reclamation staff

developed a program to implement the major features of those recommendations according to a time line that met agencies priorities and model development goals. The agencies response plan was documented in an August 2004 report, titled: PEER REVIEW RESPONSE: A Report by DWR/Reclamation in Reply to the Peer Review of the CalSim II Model Sponsored by the CALFED Science Program in December 2003.

3. In addition to the above general review of the CalSim-II modeling features and capabilities, the CALFED Science Program and the California Water and Environmental Modeling Forum jointly sponsored and oversaw a review process of the CalSim-II's updated modeling approach of the San Joaquin River Valley. The panel was chaired by Dr. J.R. Lund (University of California, Davis), and panel members were Dr. David Ford (David Ford Consulting Engineers), Mr. Les Grober (Central Valley Regional Water Quality Control Board), Dr. Thomas Harmon (University of California, Merced), and Dr. Daene McKinney (University of Texas, Austin). The panel published the results of its review in a January 12, 2006 Report, titled: Review Panel Report San Joaquin River Valley CalSim II Model Review.
4. In response to the suggestions and improvements recommended in the San Joaquin River Valley CalSim-II Panel Review Report, Reclamation and DWR developed a response document to implement the recommendations. The agencies response plan was documented in January of 2007, titled CalSim-II San Joaquin River Peer Review Response: In Reply to the Peer Review of the CalSim-II San Joaquin River Model, January 2006.

The central question put to the December 2003 external review panel was whether the CALFED program had adopted an appropriate approach to modeling the Central Valley Project/State Water Project (CVP/SWP) system. The CALFED Science Program commissioned the external review panel to provide an independent analysis and evaluation of the strengths and weaknesses of CalSim-II. The panel considered a variety of CalSim-II issues and addressed how future model development activities could be managed to assure quality results for current and proposed applications. The panel published its results in a strategic review of CalSim-II and its uses for water planning, management, and operations in central California (Close and others 2003).

In general, the panel concluded that the current modeling approach was comparable to other state-of-the-art models and addressed many of the complexities of the CVP/SWP system. To balance the competing needs of those who require greater detail from the model and those who require less detail, the panel recommended steps to achieve a more comprehensive, modular, and flexible approach in modeling practices and tools. To increase user confidence in model results and to provide a basis for gauging the model's ability to produce absolute predictive results of system behavior, the panel suggested calibration and verification of the model, as well as analyses in sensitivity and uncertainty.

The panel summarized its observation on the accuracy of the model to estimate the delivery capability of both the CVP and SWP systems in the Strategic Review's Appendix F "Analysis of the November 2003 CalSim-II Validation Report." In August 2004, DWR and the Reclamation jointly responded to the questions, comments, and recommendations of the review panel in a report, Peer Review Response: A Report by DWR/Reclamation in Reply to the Peer Review of

the CalSim-II Model Sponsored by the CALFED Science Program in December 2003. In their report, the agencies outline current and planned work on model development and the priorities for improving CalSim-II. The Peer Review Response also highlights the ongoing and planned efforts to establish trust in and credibility for the model by improving documentation, conducting sensitivity and uncertainty analyses of the model parameters and results. Other efforts include enhancing the level of detail in the geographic representation of the system, and improving hydrologic input and software development. Many of the elements of model development outlined in the Peer Review Response are in progress and will be implemented in the updated version of the model, CalSim-III.

In 2006 the CALFED Science Program and the California Water and Environmental Modeling Forum jointly sponsored a review of the CalSim-II's updated modeling approach of the San Joaquin River Valley. The review panel evaluated the model using a high standard commensurate with the important role of CalSim-II in water management decisions. They found significant improvements in the new representation of the San Joaquin River Valley over the previous formulation, making analyses of a broader range of issues possible. The final report also identifies areas of further improvement in the both the immediate future and the longer term. Since CALSIM is undergoing continuous improvement, many of the issues raised by the review have already been addressed.

## Quality Assurance and Data Quality Assessment

As described in the above section – Reliability and Acceptability of Approach, a number of peer reviews have been conducted to evaluate CalSim-II. In addition, there is on-going model development by Reclamation and DWR to continue to improve the model logic and supporting data. As part of the OCAP process, a quality assurance and independent review of the OCAP CalSim-II code and function will be conducted.

The OCAP review has the following expectations:

1. Provide feedback to OCAP development team on the form and function of OCAP modifications to the CalSim model
2. Provide suggestions for further refinement of the OCAP modifications.
3. Document the review to maintain a record of model quality assurance.

Specific review from operations perspective:

4. Review CVP and SWP export operations results.
5. Provide suggestions/alternatives for further refinement of CVP and SWP operations.

## Assumptions/Limitations

The CalSim-II model is used to simulate a 82-year period approximating future conditions under assumptions of future levels of development and historic climate conditions. The hydrologic and

operational assumptions and methods are described in DWR (2002), and Draper et al (2004). Like all models, CalSim-II has several limitations:

1. One of the main limitations of the CalSim-II model is the time step of simulation and data input. CalSim-II includes monthly hydrologic data sets and simulates operations and river flows on the same time step. Averaging flows over the monthly time step will obscure daily variations that may occur in the rivers due to dynamic system-routing effects or natural hydrologic variability. The monthly time step also requires averaging (usually day-weighted) to simulate operations for regulatory criteria that are specified for a portion of a month. The averaging process can lead to either under- or over-estimation of water availability or costs associated with the criteria.
2. The CalSim-II model also uses generalized rules to specify the operations of the CVP and SWP systems. These rules have been developed based on significant CVP/SWP operator input and represents coarse estimates of project operations over all hydrologic conditions. The results from a single CalSim-II simulation may not necessarily represent the exact operations for a specific month or year, but should reflect long-term trends.
3. CalSim-II is intended to be used in a comparative mode. The results from a “proposed operation” scenario are compared to the results of a “base” scenario, to determine the incremental effects. The model should be used with caution to prescribe seasonal or to guide real-time operations, predict flows or water deliveries for any real-time operations. The results from a single simulation may not necessarily represent the exact operations for a specific month or year, but should reflect long-term trends.
4. The model assumes that facilities, land-use, water supply contracts and regulatory requirements are constant representing a fixed level of development rather than one that varies in response to hydrologic conditions or changes over time.
5. Groundwater has only limited representation in CalSim-II and groundwater resources are the assumed mass balance “closure term”, i.e., they are infinite; there is no upper limit to groundwater pumping.
6. Water quality boundary conditions in the Delta were used from the CalSim-II Common Assumptions development effort. The sensitivity of boundary conditions patterns changing to modified assumptions and the impact this has on results has not been explored.

## Planned Future Model Development

CalSim-II outputs serve as input to numerous economic, hydrodynamic, water quality, operations, and other water planning models at both state and local levels. Therefore, developers need to enhance CalSim-II integration with other models and future development of CalSim-II is expected to focus on the integration of CalSim with models such as Agricultural Production Salinity Irrigation Drainage Economics (APSIDE) Model and DSM2.

The long term projects are summarized as follows (CalSim Joint Agency Roadmap presentation, 2006):

1. Groundwater: Implement groundwater model for SJR valley and improving conjunctive use capabilities.
2. Metadata: Focus on hydrologic and water quality data.
3. West-Side San Joaquin River Demands: model west side SJR demands based on land use and model land use response to water supply allocations.
4. WRIMS 2.1: Enhance WRMIS with interactive schematic and database replication tool.

## CalSim-II Application

### System Boundaries

The CalSim-II covers a large area including the drainage area of Sacramento and San Joaquin Rivers, the upper Trinity River, and the San Joaquin Valley, Tulare Basin, and southern California areas served by the Federal Central Valley Project (CVP) and the California State Water Project (SWP) are simulated in CalSim-II. The focus of CalSim-II is on the major CVP and SWP facilities in the Central Valley Basin, but operations of many other facilities are included to varying degrees.

### Time and Length Scales

The model output includes monthly reservoir releases, channel flows, reservoir storage volumes, and parameters describing SJR and Delta water quality conditions.

The historical flow record October 1922-September 2003, adjusted for the influence of land-use change and upstream flow regulation, is used to represent the possible range of water supply conditions.

CalSim-II models all areas that contribute flow to the San Francisco Bay-Delta. The geographical coverage includes: The Sacramento River Valley; the San Joaquin River Valley; the Sacramento-San Joaquin Delta; the Upper Trinity River and the CVP and SWP service areas. CalSim-II simulates operation of the CVP-SWP system for 82 years using a monthly time step.

### System Characteristics

The CalSim-II system is composed of the CVP and SWP systems. The CVP is composed of some 20 reservoirs with a combined storage capacity of more than 11 million acre-feet, 11 powerplants, and more than 500 miles of major canals and aqueducts. The major water facilities in the Central Valley include Shasta Lake, Keswick Reservoir, and Red Bluff Diversion Dam on the Sacramento River; Trinity Lake on the Trinity River; Whiskeytown Reservoir on Clear Creek; Lake Oroville and Thermalito Afterbay on the Feather River; Folsom Lake and Folsom South Canal on the American River; New Melones Lake on the Stanislaus River; and Millerton Lake on the San Joaquin River.

The SWP, operated and maintained by DWR, is composed of 17 pumping plants, 8 hydroelectric powerplants, 32 storage facilities, and more than 660 miles of aqueducts and pipelines. The SWP serves more than two-thirds of the State's population and approximately 600,000 acres of irrigated farmland in the Feather River area, San Francisco Bay Area, San Joaquin Valley, Central California Coast, and Southern California. The managed facilities provide water supply to contracting agencies, flood control, recreation, fish and wildlife enhancement, power generation, and salinity control in the Sacramento-San Joaquin Delta.

## **Assumptions**

The assumptions matrix in Table 5 shows the basic assumptions that are used in CalSim for each of the OCAP BA studies (defined in Chapter 9).

**Table 5. CalSim-II Modeling Assumptions**

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	OCAP BA 2004 Today CVPIA 3406 (b)(2) with EWA	Today-OCAP BA 2004 Assumptions in Revised CalSim-II Model - EWA	Today-OCAP BA 2004 Assumptions in Revised CalSim-II Model - CVPIA (b)(2) - CONV	Today- Existing Conditions, (b)(2), EWA	Near Future- Existing Conditions and OCAP BA 2004 Consulted Projects, (b)(2), Limited EWA	Future - (b)(2), Limited EWA	Future Climate Change- D1641	Model Revision s since OCAP BA 2004
OCAP Base model: Common Assumptions: Common Model Package (Version 8D)								
<i>"Same" indicates an assumption from a column to the left</i>								
Planning horizon	2001	2005 <sup>a</sup>	Same	Same	Same	2030 <sup>a</sup>	Same	
Period of Simulation	73 years (1922-1994)	82 years (1922- 2003)	Same	Same	Same	Same	Same	Extended hydrolog y timeserie s
<b>HYDROLOGY</b>							Inflows are modified based on alternative climate inputs <sup>b</sup>	Revised level of detail in the Yuba and Colusa Basin including rice decompo sition operation s
<b>Level of development (Land Use)</b>	2001 Level	2005 level	Same	Same	Same	2030 level <sup>c</sup>	Same	
<b>Sacramento Valley</b> (excluding American R.)								

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
CVP	Land-use based, limited by contract amounts <sup>d</sup>	Same	Same	Same	Same	CVP Land-use based, Full build out of CVP contract amounts <sup>d</sup>	Same	
SWP (FRSA)	Land-use based, limited by contract amounts <sup>e</sup>	Same	Same	Same	Same	Same	Same	
Non-project	Land-use based	Same	Same	Same	Same	Same	Same	
Federal refuges	Firm Level 2	Same	Same	Recent Historical Firm Level 2 water needs <sup>f</sup>	Same	Firm Level 2 water needs <sup>f</sup>	Same	
<b>American River</b>								
Water rights	2001 <sup>g</sup>	Same	Same	2005 <sup>g</sup>	Same	2025 <sup>g</sup>	Same	
CVP (PCWA American River Pump Station)	No project	Same	Same	CVP (PCWA modified) <sup>g</sup>	Same	Same	Same	
<b>San Joaquin River<sup>h</sup></b>								
Friant Unit	Regression of Historical Demands	Limited by contract amounts, based on current allocation policy	Same	Same	Same	Same	Same	Developed land-use based demands, water quality calculations, and revised accretion/s/depletions in the East-Side San Joaquin Valley
Lower Basin	Fixed Annual Demands	Land-use based, based on district level operations and constraints	Same	Same	Same	Same	Same	



	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II	
Stanislaus River	New Melones Interim Operations Plan	Same	Same	Same	Draft Transitional Operations Plan <sup>f</sup>	Same	Same	Initial storage conditions for New Melones Reservoir were increased.	
<b>South of Delta</b>									
(CVP/SWP project facilities)	CVP Demand based on contracts amounts <sup>d</sup>	Same	Same	Same	Same	Same	Same		
Contra Costa Water District	124 TAF/yr annual average	135 TAF/yr annual average CVP contract supply and water rights <sup>i</sup>	Same	Same	Same	195 TAF/yr annual average CVP contract supply and water rights <sup>i</sup>	Same		
SWP Demand - Table A	Variable 3.1-4.1 MAF/Yr	Same	Same	Variable 3.1-4.2 MAF/Yr <sup>e,j</sup>	Same	Full Table A	Same	Revised SWP delivery logic. Three patterns with Art 56 and more accurately defined Table A / Article 21 split modeled	
SWP Demand - North Bay Aqueduct (Table A)	48 TAF/Yr	Same	Same	71 TAF/Yr <sup>u</sup>	Same	Same	Same		

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
SWP Demand - Article 21 demand	Up to 134 TAF/month December to March, total of other demands up to 84 TAF/month in all months	Same	Same	Up to 314 TAF/month from December to March, total of demands up to 214 TAF/month in all other months <sup>e,jw</sup>	Same	Same	Same	
Federal refuges	Firm Level 2	Same	Same	Recent Historical Firm Level 2 water needs <sup>f</sup>	Same	Firm Level 2 water needs <sup>f</sup>	Same	
<b>FACILITIES</b>								
<b>Systemwide</b>	Existing facilities <sup>a</sup>	Same	Same	Same	Same	Same	Same	
<b>Sacramento Valley</b>								
Red Bluff Diversion Dam	No diversion constraint	Same	Same	Diversion Dam operated May 15 - Sept 15 (diversion constraint)	Same	Diversion Dam operated July - August (diversion constraint)	Same	
Colusa Basin	Existing conveyance and storage facilities	Same	Same	Same	Same	Same	Same	
Upper American River	No project	Same	Same	PCWA American River pump station <sup>k</sup>	Same	Same	Same	
Sacramento River Water Reliability	No project	Same	Same	Same	Same	American/Sacramento River Diversions <sup>l</sup>	Same	
Lower Sacramento River	No project	Same	Same	Same	Freeport Regional Water Project (Full Demand) <sup>l</sup>	Same	Same	
<b>Delta Region</b>								

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
SWP Banks Pumping Plant	South Delta Improvements Program Temporary Barriers, 6,680 cfs capacity in all months and an additional 1/3 of Vernalis flow from Dec 15 through Mar 15 <sup>a</sup>	Same	Same	Same	South Delta Improvements Program Permanent Operable Gates (Stage 1). 6,680 cfs capacity in all months and an additional 1/3 of Vernalis flow from Dec 15 through Mar 15 <sup>a</sup>	Same	Same	
CVP C.W. Bill Jones (Tracy) Pumping Plant	4,200 cfs + deliveries upstream of DMC constriction	Same	Same	Same	4,600 cfs capacity in all months (allowed for by the Delta-Mendota Canal-California Aqueduct Intertie)	Same	Same	
City of Stockton Delta Water Supply Project (DWSP)	No project	Same	Same	DWSP WTP 0 mgd	Same	DWSP WTP 30 mgd	Same	
Contra Costa Water District	Existing pump locations	Same	Same	Same	Same	Same <sup>m</sup>	Same	
<b>South of Delta (CVP/SWP project facilities)</b>								
South Bay Aqueduct (SBA)	Existing capacity 300 cfs	Same	Same	SBA Rehabilitation: 430 cfs capacity from junction with California Aqueduct to Alameda	Same	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL County FC&WSD Zone 7 diversion point	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
<b>REGULATORY STANDARDS</b>									
<b>Trinity River</b>									
	Minimum flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/year)	Same	Same	Same	Same	Same	Same	
	Trinity Reservoir end-of-September minimum storage	Trinity EIS Preferred Alternative (600 TAF as able)	Same	Same	Same	Same	Same	Same	
<b>Clear Creek</b>									
	Minimum flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to USFWS and NPS, and USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same	Same	Same	Same	Same	
<b>Upper Sacramento River</b>									
	Shasta Lake	NMFS 2004 BiOp: 1.9 MAF end of Sep. storage target in non-critical years	Same	Same	Same	Same	Same	Same	
	Minimum flow below Keswick Dam	Flows for SWRCB WR 90-5 temperature control, and	Same	Same	Same	Same	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
		USFWS discretionary use of CVPIA 3406(b)(2)							
<b>Feather River</b>									
	Minimum flow below Thermalito Diversion Dam	1983 DWR, DFG Agreement (600 cfs)	Same	Same	Same	2006 Settlement Agreement (700 / 800 cfs)	Same	Same	
	Minimum flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750-1,700 cfs)	Same	Same	Same	Same	Same	Same	
<b>Yuba River</b>									
	Minimum flow below Daguerre Point Dam	Available Yuba River Data <sup>p</sup>	D-1644 Interim Operations <sup>p</sup>	Same	Yuba Accord Adjusted Data <sup>p</sup>	Same	Same	Same	
<b>American River</b>									
	Minimum flow below Nimbus Dam	SWRCB D- 893 (see Operations Criteria), and USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same	(b)(2) Minimum Instream Flow managemen t <sup>s</sup>	Same	American River Flow Management <sup>s</sup>	Same	
	Minimum Flow at H Street Bridge	SWRCB D- 893	Same	Same	Same	Same	Same	Same	
<b>Lower Sacramento River</b>									
	Minimum flow near Rio Vista	SWRCB D- 1641	Same	Same	Same	Same	Same	Same	
<b>Mokelumne River</b>									
	Minimum flow below Camanche Dam	FERC 2916- 029, 1996 (Joint Settlement	Same	Same	Same	Same	Same	Same	

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	Agreement) (100-325 cfs)							
Stanislaus River	Minimum flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25-300 cfs)	Same	Same	Same	Same	Same	Same
	Minimum flow below Goodwin Dam	1987 USBR, DFG agreement, and USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same	Same	Same	Same	Same
Merced River	Minimum dissolved oxygen	SWRCB D-1422	Same	Same	Same	Same	Same	Same
	Minimum flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180-220 cfs, Nov-Mar), Cowell Agreement	Same	Same	Same	Same	Same	Same
Tuolumne River	Minimum flow at Shaffer Bridge	FERC 2179 (25-100 cfs)	Same	Same	Same	Same	Same	Same
	Minimum flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94-301 TAF/year)	Same	Same	Same	Same	Same	Same
San Joaquin River	Maximum salinity near Vernalis	SWRCB D-1641	Same	Same	Same	Same	Same	Same

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
<b>Sacramento River–San Joaquin River Delta</b>	Minimum flow near Vernalis	SWRCB D- 1641, and Vernalis Adaptive Management Plan per San Joaquin River Agreement	Same	Same	Same	Same	Same	Same	
	Delta Outflow Index (Flow and Salinity)	SWRCB D- 1641	Same	Same	Same	Same	Same	Same	Revised Delta ANN (salinity estimation) <sup>v</sup>
	Delta Cross Channel gate operation	SWRCB D- 1641	Same	Same	Same	Same	Same	Same	
	Delta exports	SWRCB D- 1641, USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same	Same	Same	Same	Same	
<b>OPERATIONS CRITERIA: RIVER-SPECIFIC</b>									
<b>Upper Sacramento River</b>									
<b>American River</b>	Flow objective for navigation (Wilkins Slough)	3,250 - 5,000 cfs based on CVP water supply condition	Same	Same	Same	Same	Same	Same	
	Folsom Dam flood control	Variable 400/670 flood control diagram (without outlet modifications)	Same	Same	Same	Same	Same	Same	

		Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
	Flow below Nimbus Dam	Discretionary operations criteria corresponding to SWRCB D- 893 required minimum flow	Same	Same	(b)(2) Minimum Instream Flow managemen t <sup>s</sup>	Same	American River Flow Management <sup>s</sup>	Same	
<b>Stanislaus River</b>	Sacramento Area Water Forum "Replacement " Water	"Replacement " water is not implemented	Same	Same	Same	Same	Same	Same	
	Flow below Goodwin Dam	1997 New Melones Interim Operations Plan	Same	Same	Same	Draft Transitional Operations Plan <sup>r</sup>	Same	Same	
<b>San Joaquin River</b>	Flow at Vernalis	D1641	Same	Same	Same	Same	Same <sup>q</sup>	Same	
<b>OPERATIONS CRITERIA: SYSTEMWIDE</b>									
<b>CVP water allocation</b>									
	CVP Settlement and Exchange	100% (75% in Shasta critical years)	Same	Same	Same	Same	Same	Same	
	CVP refuges	100% (75% in Shasta critical years)	Same	Same	Same	Same	Same	Same	
	CVP agriculture	100%-0% based on supply (South- of-Delta allocations are reduced due to D-1641 and 3406(b)(2) allocation- related export restrictions)	Same	Same	Same	Same	Same	Same	



	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
CVP municipal & industrial	100%-50% based on supply (South-of-Delta allocations are reduced due to D-1641 and 3406(b)(2) allocation-related export restrictions)	Same	Same	Same	Same	Same	Same	
<b>SWP water allocation</b>								
North of Delta (FRSA)	Contract specific	Same	Same	Same	Same	Same	Same	
South of Delta (including North Bay Aqueduct)	Based on supply; equal prioritization between Ag and M&I based on Monterey Agreement	Same	Same	Same	Same	Same	Same	
<b>CVP-SWP coordinated operations</b>								
Sharing of responsibility for in-basin-use	1986 Coordinated Operations Agreement (FRWP EBMUD and 2/3 of the North Bay Aqueduct diversions are considered as Delta Export, 1/3 of the North Bay Aqueduct diversion is considered as in-basin-use)	Same	Same	Same	Same	Same	Same	

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
Sharing of surplus flows	1986 Coordinated Operations Agreement	Same	Same	Same	Same	Same	Same	
Sharing of Export/Inflow Ratio	Equal sharing of export capacity under SWRCB D-1641; use of CVPIA 3406(b)(2) restricts only CVP and/or SWP exports	Same	Same	Same	Same	Same	Same	
Sharing of export capacity for lesser priority and wheeling related pumping	Cross Valley Canal wheeling (max of 128 TAF/year), CALFED ROD defined Joint Point of Diversion (JPOD)	Same	Same	Same	Same	Same	Same	
<b>Study assumptions from above apply</b>		<b>Study 6a</b>	<b>Study 7a</b>	<b>Study 7a</b>	<b>Study 7.1a</b>	<b>Study 8a</b>	<b>NA</b>	
<b>CVPIA 3406(b)(2): Per May 2003 Dept. of Interior Decision</b>								
Allocation	800 TAF, 700 TAF in 40-30-30 dry years, and 600 TAF in 40-30-30 critical years <sup>n</sup>	Same	Same	Same	Same	Same	NA	
<b>Study assumptions from above apply</b>		<b>Study 6b</b>	<b>Study 7b</b>	<b>Study 7b</b>	<b>Study 7.1b</b>	<b>Study 8b</b>	<b>NA</b>	
<b>CALFED Environmental Water Account / Limited Environmental Water Account</b>								

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
Actions	Dec-Feb reduce total exports by 50 TAF/mon relative to total exports without EWA; VAMP (Apr 15 - May 16) export restriction on SWP; Post (May 16-31) VAMP export restriction on SWP and potentially on CVP if B2 Post-VAMP action is not taken; Ramping of exports (Jun)	Dec/Jan 50 TAF/mon export reduction, Feb 50 TAF export reduction in Wet/AN years, Feb/Mar 100, 75, or 50 TAF reduction dependent on species habitat conditions; VAMP (Apr 15 - May 16) export restriction on SWP; Pre (Apr 1-14) VAMP export reduction in Dry/Crit years; Post (May 16-31) export restriction; June ramping restriction if PostVAMP action was done. Pre- and Post-VAMP and June actions done if foreseeable October debt at San Luis does not exceed 150 TAF.	NA	Same	VAMP (Apr 15 - May 16) 31-day export restriction on SWP; If stored assets and purchases from the Yuba are sufficient, Post (May 16-31) VAMP export restrictions apply to SWP <sup>pa</sup>	Same	NA	The EWA actions, assets, and debt were revised and vetted as part of the Long Term Environm ental Water Account EIS/R project

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
Assets	Fixed Water Purchases 250 TAF/yr, 230 TAF/yr in 40-30-30 dry years, 210 TAF/yr in 40-30-30 critical years. The purchases range from 0 TAF in Wet years to approximately 153 TAF in Critical years NOD, and 57 TAF in Critical years to 250 TAF in Wet years SOD. Variable assets include the following: use of 50% of any CVPIA 3406(b)(2) releases pumped by SWP, flexing of Delta E/I Ratio (post-processed from CalSim-II results), additional 500 CFS pumping capacity at Banks in Jul-Sep	Fixed Water Purchases 250 TAF/yr, 230 TAF/yr in 40-30-30 dry years, 210 TAF/yr in 40-30-30 critical years. NOD share of annual purchase target ranges from 90% to 50% based on SWP Ag Allocation as an indicator of conveyance capacity. Variable/operational assets include use of 50% of any CVPIA 3406(b)(2) releases pumped by SWP, additional 500 CFS pumping capacity at Banks in Jul-Sep, source shifting, Semitropic Groundwater Bank, "spill" of San Luis carryover debt, and backed-up stored water from Spring EWA actions.	NA	Same	Purchase of Yuba River stored water under the Lower Yuba River Accord (average of 48 TAF/yr), use of 50% of any CVPIA 3406 (b)(2) releases pumped by SWP, additional 500 CFS pumping capacity at Banks in Jul-Sep.	Same	NA	

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
Debt	Delivery debt paid back in full upon assessment; Storage debt paid back over time based on asset/action priorities; SOD and NOD debt carryover is explicitly managed or spilled; NOD debt carryover must be spilled; SOD and NOD asset carryover is allowed	Same	NA	Same	No Carryover Debt	Same	NA	

**Post Processing Assumptions**

**WATER MANAGEMENT ACTIONS (CALFED)**

**Water Transfers**

Water transfers	Acquisitions by SWP contractors are wheeled at priority in Banks Pumping Plant over non-SWP users	Same	NA	Same	Same	Same	NA	
Phase 8 <sup>o</sup>	Evaluate available capacity	Same	NA	Same	Same	Same		
Refuge Level 4 water	Evaluate available	Same	NA	Same	Same	Same		

Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
capacity							

**Notes:**

<sup>a</sup> The OCAP BA project description is presented in Chapter 2.

<sup>b</sup> Climate change sensitivity analysis assumptions and documentation are presented in Appendix R.

<sup>c</sup> The Sacramento Valley hydrology used in the CALSIM II model reflects 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation. Development of 2030 land-use assumptions are being coordinated with the California Water Plan Update for future models.

<sup>d</sup> CVP contract amounts have been reviewed and updated according to existing and amended contracts as appropriate. Assumptions regarding CVP agricultural and M&I service contracts and Settlement Contract amounts are documented in Table 3A (North of Delta) and 5A (South of Delta) of Appendix D: Delivery Specifications section of the Technical Appendix.

<sup>e</sup> SWP contract amounts have been reviewed and updated as appropriate. Assumptions regarding SWP agricultural and M&I contract amounts are documented in Table 1A (North of Delta) and Table 2A (South of Delta) of Appendix D: Delivery Specifications section.

<sup>f</sup> Water needs for federal refuges have been reviewed and updated as appropriate. Assumptions regarding firm Level 2 refuge water needs are documented in Table 3A (North of Delta) and 5A (South of Delta) of Appendix D: Delivery Specifications. Incremental Level 4 refuge water needs have been documented as part of the assumptions of future water transfers.

<sup>g</sup> PCWA demand in the foreseeable existing condition is 8.5 TAF/yr of CVP contract supply diverted at the new American River PCWA Pump Station. In the future scenario, PCWA is allowed 35 TAF/yr. Assumptions regarding American River water rights and CVP contracts are documented in Table 5 of Appendix D: Delivery Specifications section.

<sup>h</sup> The new CalSim-II representation of the San Joaquin River has been included in this model package (CalSim-II San Joaquin River Model, Reclamation, 2005). Updates to the San Joaquin River have been included since the preliminary model release in August 2005. The model reflects the difficulties of on-going groundwater overdraft problems. The 2030 level of development representation of the San Joaquin River Basin does not make any attempt to offer solutions to on-going groundwater overdraft problems. In addition, a dynamic groundwater simulation is not yet developed for San Joaquin River Valley. Groundwater extraction/ recharge and stream-groundwater interaction are static assumptions and may not accurately reflect a response to simulated actions. These limitations should be considered in the analysis of results.

Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
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<sup>i</sup> Study 6.0 demands for CCWD are assumed equal to Study 7.0 due to data availability with the revised CalSim-II model framework. For all Studies, Los Vaqueros Reservoir storage capacity is 100 TAF.

<sup>j</sup> Table A deliveries into the San Francisco Bay Area Region for existing cases are based on a variable demand and a full Table A for future cases. The variable demand is dependent on the availability of other water during wet years resulting in less demand for Table A. In the future cases it is assumed that the demand for full Table A will be independent of other water sources. Article 21 demand assumes MWD demand of 100 TAF/mon (Dec-Mar), Kern demand of 180 TAF/mon (Jan-Dec), and other contractor demand of 34 TAF/mon (Jan-Dec).

<sup>k</sup> PCWA American River pumping facility upstream of Folsom Lake is under construction.

<sup>l</sup> Mokelumne River flows reflect EBMUD supplies associated with the Freeport Regional Water Project.

<sup>m</sup> The CCWD Alternate Intake Project (AIP), an intake at Victoria Canal, which operates as an alternate Delta diversion for Los Vaqueros Reservoir is not included in Study 8.0. AIP is included as a separate consultation. AIP will be further evaluated after regulatory and operational management assumptions have been determined.

<sup>n</sup> The allocation representation in CalSim-II replicates key processes, shortage changes are checked by post-processing.

<sup>o</sup> This Phase 8 requirement is assumed to be met through Sacramento Valley Water Management Agreement Implementation.

<sup>p</sup> OCAP BA 2004 modeling used available hydrology at the time which was data developed based on 1965 Yuba County Water Agency -Department of Fish of Game Agreement. Since the OCAP BA 2004 modeling, Yuba River hydrology was revised. Interim D-1644 is assumed to be fully implemented with or without the implementation of the Lower Yuba River Accord. This is consistent with the future no-action condition being assumed by the Lower Yuba River Accord EIS/EIR study team. For studies with the Lower Yuba River Accord, an adjusted hydrology is used.

<sup>q</sup> It is assumed that either VAMP, a functional equivalent, or D-1641 requirements would be in place in 2030.

<sup>r</sup> The Draft Transitional Operations Plan assumptions are discussed in Chapter 2.

<sup>s</sup> For Studies 7.0, 7.1, and 8.0 the flow components of the proposed American River Flow Management are included and applied using the CVPIA 3406(b)(2). For Study 8.0 the American River Flow Management is assumed to be the new minimum instream flow.

<sup>t</sup> OCAP assumes the flexibility of diversion location but does not assume the Sacramento Area Water Forum Water Forum "replacement water" in drier water year types.

	Study 3a	Study 6.0 COMPARISON	Study 6.1 COMPARISON	Study 7.0 BASE MODEL	Study 7.1 ANALYTICAL	Study 8.0 ANALYTICAL	Study 9.0 - 9.5 SENSITIVITY	CalSim-II
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<sup>u</sup> Aqueduct improvements that would allow an increase in South Bay Aqueduct demand at the time of model development were expected to be operational within 6 months. However, a delay in the construction has postponed the completion.

<sup>v</sup>The Artificial Neural Network (ANN) was updated for both salinity and X2 calculations. Study 3a does not include an updated ANN, Study 6.1 has an updated salinity but not X2, and all remaining Studies include both the updated salinity and X2.

<sup>w</sup> North Bay Article 21 deliveries are dependent on excess conditions rather than being dependent on San Luis storage.



## Historical Comparison

Comparison of CalSim-II predictions with observed historical estimates helps establish the credibility of the model and provides estimates of its accuracy by comparing its performance to actual historical operations. A historical comparison was conducted for CVP and SWP operations in the Historical Operations Study of water years 1975 to 1998 (DWR 2003).

The documented comparison of historical and simulated records (from the early 1983 to 2003) for CalSim-II San Joaquin River Basin show the frequency of peaks and troughs coinciding from visual inspection. This information affirms water entering and leaving the system is occurring with approximately the same timing and strengthens confidence of the timing of the operational logic (DWR and Reclamation, 2007).

## Sensitivity/Uncertainty in Inputs

Sensitivity analysis explores and quantifies the effects of various inputs on the model outputs. In 2005, DWR released a sensitivity study of 21 input parameters under D-1641 regulatory environment that developed a sensitivity index (SI) and elasticity index (EI). Key input parameters that significantly affect SWP operations are discussed to show how the SWP delivery and other operations respond to the changes in model inputs (DWR, 2005).

In 2007, another sensitivity study was released by DWR and Reclamation on CalSim-II San Joaquin River model (DWR and Reclamation, 2007). The study analyzed variables estimated in water budget analysis such as deep percolation, non-recoverable loss, irrigation efficiency, minimum ground water pumping and distribution losses. Other important parameters examined include water quality loads, land use estimates, consumptive use parameters, inflows and accretions.

## Reporting Metrics

There are many different general categories of CalSim-II model output metrics. A general list of parameters presented in the OCAP BA includes:

- End of September Storage
- River Flows
- CalSim Delta Parameters
- Allocation Percentage
- Deliveries
- D1641 WQCP parameters
- (b)(2)
  - Average monthly costs
  - Probability Exceedance
  - Requested Export Actions vs. Amount used
  - Percent of possible actions triggered

- EWA
  - Probability Exceedance VAMP expenditures
  - Expenditures by water year type
  - Expenditures not repaid
  - Probability Exceedance carryover debt
  - Probability Exceedance Purchases NOD and SOD
  - Probability Exceedance Total Acquired Assets
  - Annual Carryover Debt spill/SWP San Luis
  - Annual Expenditure Targets by water year type
  - Annual Assets by water year
  - Annual debt
  - Total Export reductions by water year
- **Delta**
  - X2 position
  - EI Ratio
  - Deliveries
  - Inflow
  - Outflow
  - Exports

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## Appendix D-Attachment 1

### Delivery Specifications: OCAP Study 7.0 (Today – Existing Conditions)

This attachment describes the State Water Project (SWP) and Central Valley Project (CVP) contract amounts and other water rights assumptions used in the OCAP Study 7.0 – Existing Conditions.

This document does not include CVP contract or water rights assumptions for the East San Joaquin River Region. Table 1 summarizes the SWP and CVP demands described in this document.

**Table 1 – Summary of SWP and CVP Demand/Contract Assumptions in the OCAP Study 7.0 – Existing Conditions (TAF/year)**

	North-of-the-Delta	South-of-the-Delta
CVP Contractors		
• Settlement/Exchange	2,194	840
Water Service Contracts		
• Agriculture	378	1,927
• M&I <sup>1</sup>	356	164
• Refuges	157	305
SWP Contractors		
• Feather River Service Area	796	0
Table A		
• Ag	0	1,048
• M&I	108	3,008

<sup>1</sup> North of Delta CVP M&I demands include Delta demands

## State Water Project

Table 2 shows the SWP Table A amounts and Article 21 demands for each North-of-the-Delta contractor. In addition, the table shows Feather River Service Area water rights.

Table 3 shows the SWP Table A amounts and Article 21 demands for each South-of-the-Delta contractor. In addition, the table shows assumed losses on the California Aqueduct.

## Central Valley Project

Table 4 shows the CVP contract amounts, Settlement Contractor and Exchange Contractor contract amounts, and firm Level 2 refuge water demands for the North-of-the-Delta region. The same type of information for the American River portion of the system is shown separately in Table 5.

Table 6 shows the CVP contract amounts, Settlement Contractor and Exchange Contractor contract amounts, other non-CVP water rights, firm Level 2 refuge water demands, and assumed losses for the South-of-the-Delta region.

Table 7 provides tables that list the CVP Settlement Contractors included in each Sacramento River miscellaneous users delivery arc. These provide additional detail for assumptions contained in Table 4.

**Table 2. SWP North-of-the-Delta - OCAP Study 7.0 - Existing Conditions**

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	FRSA Amount (TAF)	Water Right (TAF/yr)	Table A Amount (TAF)		Article 21 Demand (TAF/mon)	Other (TAF/yr)
					Ag	M&I		
<b>Feather River</b>								
Palermo	FRSA	D6		17.6				
County of Butte	Feather River	D201				27.5		
Thermalito	FRSA	D202		8.0				
Western Canal	FRSA	D7A	150.0	145.0				
Joint Board	FRSA	D7B	550.0	5.0				
City of Yuba City	Feather River	D204				9.6		
Feather WD	FRSA	D206A	17.0					
Garden, Oswald, Joint Board	FRSA	D206B						
Garden	FRSA	D206BA	12.9	5.1				
Oswald	FRSA	D206BB	2.9					
Joint Board	FRSA	D206BC	50.0					
Plumas, Tudor	FRSA	D206C						
Plumas	FRSA	D206CA	8.0	6.0				
Tudor	FRSA	D206CB	5.1	0.2				
Total Feather River Area			795.8	186.9	0.0	37.1		
<b>Other</b>								
Yuba County Water Agency	Yuba River	D230						Variable 296.2
Camp Far West ID	Yuba River	D285						12.6
South Sutter WD	American R/DSA70	D283						Variable 99.2
Feather River Exports to American River (left bank to DSA70)	American R/DSA70	D223						11.0
<b>Delta</b>								
Napa County FC&WCD	North Bay Aqueduct	D403B				23.2	1.0	
Solano County WA	North Bay Aqueduct	D403C				47.4	1.0	
Fairfield, Vacaville and Benecia Agreement	North Bay Aqueduct	D403D		31.6				
Total North Bay Aqueduct						70.6	2.0	

**Table 3. SWP South-of-the-Delta - OCAP Study 7.0 - Existing Conditions**

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Table A Amount (TAF)		Article 21 Demand (TAF/mon)	Losses (TAF/yr)
			Ag	M&I		
Alameda Co. FC&WCD, Zone 7	SBA reaches 1-4	D810		47.60	1.00	
	SBA reaches 5-6	D813		33.00	None	
		Total		80.60	1.00	
Alameda County WD	SBA reaches 7-8	D814		42.00	1.00	
Santa Clara Valley WD	SBA reach 9	D815		100.00	4.00	
Oak Flat WD	CA reach 2A	D802	5.70		None	
County of Kings	CA reach 8C	D847	9.31		None	
Dudley Ridge WD	CA reach 8D	D849	57.34		1.00	
Empire West Side ID	CA reach 8C	D846	3.00		1.00	
Kern County Water Agency	CA reaches 3, 9-13B	D851	582.31	134.60	None	
	CA reaches 14A-C	D859	118.80		180.00	
	CA reaches 15A-16A	D863	66.42		None	
	CA reach 31A	D867	96.60		None	
		Total		864.13	134.60	None
Tulare Lake Basin WSD	CA reaches 8C-8D	D848	95.92		15.00	
San Luis Obispo Co. FC&WCD	CA reaches 33A-35	D869		25.00	None	
Santa Barbara Co. FC&WCD	CA reach 35	D870		45.49	None	
Antelope Valley-East Kern WA	CA reaches 19-20B, 22A-B	D877		141.40	1.00	
Castaic Lake WA	CA reach 31A	D868	12.70		1.00	
	CA reach 30	D896		82.50	None	
		Total	12.70	82.50	1.00	
Coachella Valley WD	CA reach 26A	D883		121.10	2.00	
Crestline-Lake Arrowhead WA	CA reach 24	D25		5.80	None	
Desert WA	CA reach 26A	D884		50.00	5.00	
Littlerock Creek ID	CA reach 21	D879		2.30	None	
Mojave WA	CA reaches 19, 22B-23	D881		75.80	None	

**Table 3. SWP South-of-the-Delta - OCAP Study 7.0 - Existing Conditions**

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Table A Amount (TAF)		Article 21 Demand (TAF/mon)	Losses (TAF/yr)
			Ag	M&I		
Metropolitan WDSC	CA reach 26A	D885		148.67	45.35	
	CA reach 30	D895		756.69	37.40	
	CA reaches 28G-H	D899		102.71	13.80	
	CA reach 28J	D27		903.43	3.45	
	Total			1911.50	100.00	
Palmdale WD	CA reaches 20A-B	D878		21.30	None	
San Bernardino Valley MWD	CA reach 26A	D886		102.60	None	
San Gabriel Valley MWD	CA reach 26A	D887		28.80	None	
San Gorgonio Pass WA	CA reach 26A	D888		17.30	None	
Ventura County FCD	CA reach 29H	D28		3.15	None	
	CA reach 30	D29		16.85	None	
	Total			20.00		
SWP Losses	CA reaches 1-2	D803				7.70
	CA reach 3	D824				10.80
	CA reach 4	D826				2.60
	CA reach 5	D827				3.90
	CA reach 6	D828				1.20
	CA reach 7	D829				1.60
	CA reaches 8C-13B	D854				11.90
	Wheeler Ridge PP and CA reaches 14A-C	D862				3.60
	Chrisman PP and CA reaches 15A-18A	D864				1.80
	Pearblossom PP and CA reaches 17-21	D880				5.10
	Mojave PP and CA reaches 22A-23	D882				4.00
	REC and CA reaches 24-28J	D889				1.40
	CA reaches 29A-29F	D891				1.90
	Castaic PWP and CA reach 29H	D893				3.10
	REC and CA reach 30	D894				2.40
SBA reaches 1-9	D816				0.60	
Total						63.60
Total			1048.10	3008.09	312.00	63.60



**Table 4. CVP North-of-the-Delta - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	Geographic Location	CALSIM II Represent ation Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)
			AG	M&I			
Anderson Cottonwood ID	Sacramento River Redding Subbasin	D104A			128.0		
Clear Creek CSD		D104B	13.8	1.5			
Bella Vista WD		D104C	22.1	2.4			
Shasta CSD		D104D		1.0			
Sac R. Misc. Users		D104F			3.4		
Redding, City of		D104G			21.0		
City of Shasta Lake		D104H	2.5	0.3			
Mountain Gate CSD		D104I		0.4			
Shasta County Water Agency		D104J	0.5	0.5			
Redding, City of/Buckeye		D104K		6.1			
Total		D104	38.9	12.2	152.4		0.0
Corning WD		Corning Canal	D171	23.0			
Proberta WD	D171		3.5				
Thomes Creek WD	D171		6.4				
Total			32.9	0.0	0.0		0.0
Kirkwood WD	Tehama-Colusa Canal	D172	2.1				
Glide WD		D174	10.5				
Kanawha WD		D174	45.0				
Orland-Artois WD		D174	53.0				
Colusa, County of		D178	20.0				
Colusa County WD		D178	62.2				
Davis WD		D178	4.0				
Dunnigan WD		D178	19.0				
La Grande WD		D178	5.0				
Westside WD		D178	65.0				
Total		285.8	0.0	0.0		0.0	
Sac. River Misc. Users	Sacramento River	D113A			1.5		
Glenn Colusa ID	Glenn-Colusa Canal	D143A			825.0		
		D145A					
Sacramento NWR		D143B					41.3
Delevan NWR		D145B					19.5
Colusa NWR	D145B					24.5	
Colusa Drain M.W.C.	Colusa Basin Drain	D180			70.0		
		D182A/ D18302					
Total			0.0	0.0	895.0		85.4

**Table 4. CVP North-of-the-Delta - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	Geographic Location	CALSIM II Representation Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)
			AG	M&I			
Princeton-Cordova-Glenn ID	Sacramento River	D122A			67.8		
Provident ID		D122A			54.7		
Maxwell ID		D122A			18.0		
		D122B					
Sycamore Family Trust		D122B			31.8		
Roberts Ditch IC		D122B			4.4		
Sac R. Misc. Users		D122A			4.9		
		D122B			9.5		
<b>Total</b>			0.0	0.0	191.2		0.0
Reclamation District 108	Sacramento River	D122B			232.0		
		D129A					
River Garden Farms		D129A			29.8		
Meridian Farms WC		D128			35.0		
Pelger Mutual WC		D128			8.9		
Reclamation District 1004		D128			71.4		
Carter MWC		D128			4.7		
Sutter MWC		D128			<b>226.0</b>		
Tisdale Irrigation & Drainage Co.		D128			9.9		
Sac R. Misc. Users		D128			103.4		
		D129A			0.9		
Feather River WD export		D128	20.0				
<b>Total</b>				20.0	0.0	722.1	
Sutter NWR	Sutter bypass water for Sutter NWR	C136B					<b>14.0</b>
Gray Lodge WMA	Feather River	C216B					<b>41.4</b>
Butte Sink Duck Clubs		C221					15.9
<b>Total</b>			0.0	0.0	0.0		71.3

**Table 4. CVP North-of-the-Delta - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	Geographic Location	CALSIM II Representation Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)
			AG	M&I			
Sac R. Misc. Users	Sacramento River	D163			56.8		
City of West Sacramento		D165			23.6		
Total				0.0	0.0	80.4	
Sac R. Misc. Users	Lower Sacramento River	D162A			4.8		
Natomas Central MWC		D162B			120.2		
Pleasant Grove-Verona MWC		D162C			26.3		
City of Sacramento (PCWA)		D162D				81.8	
Total					0.0	151.3	
City of Vallejo	City of Vallejo	D403A		16.0			
CCWD <sup>c</sup>	Contra Costa County	D408		140.0 <sup>c</sup>			
Total				211.0			
Total CVP North-of-Delta			377.6	223.2	2193.8	81.8	156.7

<sup>a</sup> Level 4 Refuge water needs are not included.

<sup>b</sup> Refer to Table 7 for more information

<sup>c</sup> The new Los Vaqueros module in CALSIM II is used to determine the range of demands that are met by CVP contracts or other water rights.

**Table 5. CVP and Water Rights for American River - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement/ Exchange Contractor (TAF/yr)	Water Rights/ Non-CVP (TAF/yr)	Folsom Unimpaired Inflow (FUI) (TAF/yr)			Foot-notes (on following page)	
			AG	M&I			If FUI (Mar-Nov Folsom Unimpaired Inflow - TAF/yr)				
							> 1600	> 950	< 400		
Placer County Water Agency	Auburn Dam Site	D300		0.0		8.5	8.5	8.5	8.5	1/2/3	
Northridge Water District	Folsom Reservoir	D8A				17.0	17.0	0.0	0.0	4/5/9	
City of Folsom (includes P.L. 101-514)		D8B		7.0		27.0	34.0	34.0	34.0	1/2/3	
Folsom Prison		D8C				2.0	2.0	2.0	2.0		
San Juan Water District (Placer County)		D8D				17.0	17.0	17.0	17.0	1/2/3/9	
San Juan Water District (Sac County) (includes P.L. 101-514)		D8E		11.2		33.0	44.2	38.7	38.7	1/2/3	
El Dorado Irrigation District		D8F		7.55		0.0	7.55	7.55	7.55	1/2/3	
El Dorado Irrigation District (P.L. 101-514)		D8F		4.00			4.00	4.00	4.00	1/2/3	
City of Roseville		D8G		32.0		5.0	37.0	37.0	37.0	1/2/3/9	
Placer County Water Agency		D8H		35.0			35.0	35.0	35.0		
El Dorado County (P.L. 101-514)		D8I		15.0			15.0	15.0	15.0		
<b>Total</b>				<b>0.0</b>	<b>111.8</b>	<b>0.0</b>	<b>101.0</b>	<b>212.8</b>	<b>190.3</b>	<b>190.3</b>	
So. Cal WC/ Arden Cordova WC		Folsom South Canal	D9AA				5.0	5.0	5.0	5.0	
California Parks and Recreation	D9AB			1.0			1.0	1.0	1.0		
SMUD (export)	D9B			5.0		15.0	20.0	20.0	20.0	1/2/3	
Canal Losses	D9A					1.0	1.0	1.0	1.0		
<b>Total</b>				<b>0.0</b>	<b>6.0</b>	<b>0.0</b>	<b>21.0</b>	<b>27.0</b>	<b>27.0</b>	<b>27.0</b>	
City of Sacramento	Lower American River	D302A & D167A				49.0	49.0	49.0	49.0	6/7/8	
Arcade Water District		D302B								12	
Carmichael Water District		D302C				12.0	12.0	12.0	12.0		
<b>Total</b>				<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>61.0</b>	<b>61.0</b>	<b>61.0</b>	<b>61.0</b>	
Sacramento County Water Agency (SMUD transfer)	Lower Sacramento River	D167B/D168B		0.0			0.0	0.0	0.0	10	
Sacramento County Water Agency (P.L. 101-514)		D168B		15.0			15.0	15.0	15.0	10	
Sacramento County Water Agency - assumed Appropriated Water		D168B				0.0				10	
EBMUD (export)		D168C		0.0						11	
<b>Total</b>				<b>0.0</b>	<b>15.0</b>	<b>0.0</b>	<b>0.0</b>	<b>15.0</b>	<b>15.0</b>	<b>15.0</b>	
<b>Total</b>			<b>0.0</b>	<b>132.8</b>	<b>0.0</b>	<b>191.5</b>	<b>324.3</b>	<b>301.8</b>	<b>301.8</b>		

1/ Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 950 TAF

2/ Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 950 TAF but greater than 400 TAF

3/ Driest years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 400 TAF

4/ Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 1,600,000 af.

5/ Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 1,600 TAF

**Table 5. CVP and Water Rights for American River - OCAP Study 7.0 - Existing Conditions**

6/ Diversions for the City of Sacramento occur at the E. A. Fairbairn Water Treatment Plant if American River flows exceed the "Hodge flows H Street criteria" (Wet to Normal).

7/ Diversions for the City of Sacramento occur off the Sacramento River when American River flows do not exceed the "Hodge flows H Street criteria" (Dry to Critical).

8/ For modeling purposes, it is assumed that the City of Sacramento's total annual diversions from the American and Sacramento River would be 130.6 TAF

9/ Water Rights Water provided by releases from PCWA's Middle Fork Project; inputs into upper American River model must be consistent with these assumptions.

10/ SCWA targets 68 TAF of surface water supplies annually. The portion unmet by CVP contract water is assumed to come from two sources:

(1) Delta "excess" water- averages 14.9 TAF annually, but varies according to availability. SCWA is assumed to divert excess flow in the Delta when it is available, and when it has the available pumping capacity.

(2) "Other" water- derived from transfers and/or other appropriated water, averaging 14 TAF annually but varying according to availability of

11/ EBMUD CVP diversions are governed by the Amendatory Contract, stipulating:

(1) 133 TAF maximum diversion in any given year

(2) 165 TAF maximum diversion amount over any 3 year period

(3) Diversions allowed only when EBMUD total storage drops below 500 TAF

(4) 155 cfs maximum diversion rate

12/ Arcade WD demand was combined with the City of Sacramento demands.

**Table 6. CVP South-of-the-Delta - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)	Losses (TAF/yr)
			AG	M&I				
Byron-Bethany ID	Upper DMC	D700	20.6					
Tracy, City of		D700		10.0				
		D700		5.0				
Banta Carbona ID		D700	20.0					
Total		D700	40.6	20.0	0.0	0.0	0.0	0.0
Del Puerto WD	Upper DMC	D701	12.1					
Davis WD		D701	5.4					
Foothill WD		D701	10.8					
Hospital WD		D701	34.1					
Kern Canon WD		D701	7.7					
Mustang WD		D701	14.7					
Orestimba WD		D701	15.9					
Quinto WD		D701	8.6					
Romero WD		D701	5.2					
Salado WD		D701	9.1					
Sunflower WD		D701	16.6					
West Stanislaus WD		D701	50.0					
Patterson WD		D701	16.5			6.0		
Westlands WD #1 (Centinella WD)		D701	0.0					
Total		D701	206.7	0.0	0.0	6.0	0.0	0.0
Upper DMC Loss	Upper DMC	D702						18.5
Panoche WD	Lower DMC Volta	D706	6.6					
San Luis WD		D706	65.0					
Broadview WD		D706	27.0					
Laguna WD		D706	0.8					
Eagle Field WD		D706	4.6					
Mercy Springs WD		D706	2.8					
Westlands WD #2		D708	0.0					
Oro Loma WD		D706	4.6					
Westlands WD #1 (Widren WD)		D706	0.0					
Total		D706	111.4	0.0	0.0	0.0	0.0	0.0
Upper DMC Exchange Contractors	Lower DMC Volta	D707						
Central California ID		D707			140.0			
Grasslands via CCID	Lower DMC Volta	D708					<b>81.8</b>	
Los Banos WMA		D708					<b>11.2</b>	

**Table 6. CVP South-of-the-Delta - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)	Losses (TAF/yr)
			AG	M&I				
Kesterson NWR	Lower DMC Volta	D708					19.6	
Freitas - SJBAP		D708					6.9	
Salt Slough - SJBAP		D708					10.3	
China Island - SJBAP		D708					7.2	
Volta WMA		D708					15.9	
Grassland via Volta Wasteway		D708					23.2	
<b>Total</b>		D708	0.0	0.0	0.0	0.0	176.1	0.0
Westlands WD (incl. Barcellos)	Mendota Pool	D607A	0.0					
Fresno Slough WD		D607A/D607B	4.0			0.9		
James ID		D607A/D607B	35.3			9.7		
Coelho Family Trust		D607A/D607B	2.1			1.3		
Tranquillity ID		D607A/D607B	13.8			20.2		
Tranquillity PUD		D607A/D607B	0.1			0.1		
Reclamation District 1606		D607A/D607B	0.2			0.3		
Exchange Contractors		D607B						
Central California ID		D607B			392.4			
Columbia Canal Co.		D607B			59.0			
Firebaugh Canal Co.		D607B			85.0			
San Luis Canal Co.		D607B			163.6			
M.L. Dudley Company		D607B				2.3		
Grasslands WD		D607C					31.3	
Los Banos WMA		D607C					12.4	
San Luis NWR		D607C					23.8	
Mendota WMA		D607C					37.9	
West Bear Creek NWR		D607C					7.5	
East Bear Creek NWR		D607C					0.0	
Losses		D607D						101.5
<b>Total</b>	D607	55.5	0.0	700.0	34.8	112.9	101.5	
San Benito County WD (Ag)	San Felipe	D710	35.6					
Santa Clara Valley WD (Ag)		D710	33.1					
Pajaro Valley WD		D710	6.3					
San Benito County WD (M&I)		D711		8.3				
Santa Clara Valley WD (M&I)		D711		119.4				
<b>Total</b>		D710/D711	74.9	127.7	0.0	0.0	0.0	0.0





**Table 6. CVP South-of-the-Delta - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)	Losses (TAF/yr)	
			AG	M&I					
Cross Valley Canal - CVP	CA reach 14								
Fresno, County of		D855	3.0						
Hills Valley ID-Amendatory		D855	3.3						
Kern-Tulare WD		D855	40.0						
Lower Tule River ID		D855	31.1						
Pixley ID		D855	31.1						
Rag Gulch WD		D855	13.3						
Tri-Valley WD		D855	1.1						
Tulare, County of		D855	5.3						
Kern NWR		D856					14.3		
Pixley NWR		D856					1.3		
Total				128.3	0.0	0.0	0.0	15.6	0.0
Total CVP South-of-Delta				1927.4	164.2	840.0	44.3	304.6	183.7

<sup>a</sup> Level 4 Refuge water needs are not included

**Table 7. Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc location - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)			
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total	
Riverview Golf & Country Club	D104F	58	3	240.8	L	255	25	280	
Daniell, Harry				240.3	L	13	7	20	
Redding Rancheria (Fmrly High-Low Nursery)				240.2	L	70	135	205	
Lake Cal. Property Owners Assn			2	221	R	580	200	780	
Leviathan, Inc.				221	R	355	345	700	
Driscoll Strawberry Associates, Inc.				207.5	L	330	490	820	
J. B. Unlimited, Inc.			3	197	L	220	290	510	
Micke, Daniel & Nina				196.6	L	81	19	100	
Gjermann, Hal				196.55	L	8	4	12	
<b>Total</b>			D104F					1,912	1,515
Meyer, Herbert (Fmrly Diamond Holdings, Inc.)	D113A	58	4	191.5	R	195	230	425	
Exchange Bank (The Nature Conservancy)				168.85	R	210	570	780	
Rubio, Exequiel (Fmrly Elliott&Hadracky)				166.8	R	11	5	16	
Penner, Roger & Leona				156.8	R	159	21	180	
Freeman, Vola				156.1	R	11	19	30	
Mclane, Robert				155.6	R	17	23	40	
Alexander, Thomas Et Ux				155.6	R	9	13	22	
<b>Total</b>				D113A					612
Green Valley Corp. (Fmrly Cannell, F.)	D122A	15	8NN	106	R	680	210	890	
Green Valley Corp. (Fmrly Stegeman Ranch)				106	R	555	325	880	
Tuttle, Charles W. - Trust				103.9	R	120	270	390	
Cachil Dehe Band Of Wintun Indians(Lee Farms)				103.7	R	80	100	180	
Seaver, Charles				99.3	R	200	260	460	
Odysseus Farms				93.15	R	1,920	150	2,070	
<b>Total</b>				D122A					3,555
King, Ben And Laura (Fmrly Dommer, E.)	D122B	15	8NS	89.2	R	12	7	19	
King, Laura				89.2	R	13	13	26	
Wisler, John W. Jr. (Fmrly Cribari, E.)				88	R	8	27	35	
Mehrhof, Susan M.(fmrly.Swinford Tract)				87.7	R	164	16	180	
Steidlmayer, Anthony E., Et Al.				83	R	610	700	1,310	
Jansen, Peter & Sandy (Fmrly E. J. Ritchey)				70.4	R	150	40	190	
Gillaspy, William & Mary (Fmrly Fay Gillaspy)				70.4	R	120	90	210	
Beckley, Ralph, And Ophelia				70.4	R	165	135	300	
Driver, Gary, Et Al.				69.2	R	8	22	30	
Heidrick, Mildred M.				30.6	R	86	34	120	
Tenhunfeld, F. Wallace, Jack, Et Al.		65	29.7	R	2,680	960	3,640		
Heidrick, Mildred M.			29.2, 30.3	R	370	60	430		
Hershey Land Company			28.1	R	2,570	450	3,020		
<b>Total</b>			D122B					6,956	2,554

**Table 7. Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc location - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)				
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total		
Pacific Realty Assoc., L.P. (M&T Chico Ranch)	D128	15	9	140.8, 141.5	L	16,980	976	17,956		
Spence, Ruth Ann (Spence Farms)				104.8	L	630	100	730		
Anderson, Arthur Et Al (Frmrly Westfall, Mary)				102.5	L	445	45	490		
Forry, Laurie E.				99.8	L	2,285	0	2,285		
Otterson, Mike (Frmrly Wells Joyce M.)				98.9	L	1,515	300	1,815		
Nene Ranch, Llc (Frmrly Hollins, Mariette B.)				98.6	L	1,360	200	1,560		
Griffin, Josphe, Et Al.				95.8	L	1,610	1,150	2,760		
Baber, Jack Et Al.				95.6	L	3,630	2,630	6,260		
Eastside Mwc (Frmrly A&F Boeger Corp.)				95.25	L	2,170	634	2,804		
Zelmar Ranch, Inc. (Frmrly Martin, Andrew)				92.5	L	112	52	164		
Gomes, Judith (Frmrly. Martin, Andrew)				92.5	L	168	78	246		
Butte Creek Farms				89.26	L	20	16	36		
Butte Creek Farms				89.24	L	40	55	95		
Butte Creek Farms (Frmrly Mayfair Farms)				88.7	L	196	8	204		
Butte Creek Farms(Area 1)				88.7	L	300	340	640		
Howard, Theodore W. And Linda M.				88.7	L	74	2	76		
Locvich, Paul				88.2	L	80	70	150		
Ehrke, Allen A. Et Ux				86.8	L	220	160	380		
Fedora, Sib Et Al.			82.7	L	190	20	210			
Reische, Laverne Et Ux			82.5	L	183	267	450			
Reische, Eric			82.5	L	37	53	90			
Tarke, Stephen & Debra			81.5	L	1,700	1,000	2,700			
Churkin, Michael, Et Al.			79.5	L	75	55	130			
Eggleston, Ronald Et Ux			79	L	53	12	65			
Hale, Judith Et Al.			79	L	117	13	130			
Hale, Judith Et Al.			79	L	58	17	75			
Pires, Lawrence And Beverly			77.9	L	185	95	280			
Davis, Ina M.			76.2	L	71	14	85			
Chesney, Adona (R & A, Bypass Trust)			76.15	L	310	390	700			
Andreotti, Beverly F., Et Al.			72.1	L	2,060	1,560	3,620			
Mclaughlin, Jack			72	L	430	220	650			
Lomo Cold Storage (& J. J. Micheli)			67.5	L	6,410	700	7,110			
Anderson, R And J, Prop.			67.1	L	149	88	237			
Lonon, Michael Et Al.			67.1	L	715	440	1,155			
Oji Brothers Farm, Inc.			63.9	L	1,340	1,860	3,200			
Young, Russell, Et Al.			63.3	L	2	8	10			
Sekhon, Arjinderpal & Daljit			62.3	L	350	470	820			
Butler, Leslie A., Et Ux			60.5, 61.8	L	180	280	460			
Howald Farms Inc.			60.4	L	1,350	1,410	2,760			
Kary, Carol			59.8	L	400	600	1,000			
					18					

**Table 7. Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc location - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Dennis Wilson Farms (Frmrly M&L Farms (Area 1))	D128	15	19	58.9	L	295	60	355
Lockett, William P. & Jean B.				58.3	L	370	47	417
O'brien, Janice				58.3	L	550	289	839
Wirth, Marilyn L. (Frmrly Davis, Marilyn)				57.75	L	180	340	520
Bardis, C. Et Al 9(Reynen/Broomieside Farms)				55.1	L	8,070	2,000	10,070
Wakida, Tomio				53.9	L	50	275	325
Wakida, Tomio				52.3	L	25	135	160
Nelson, Thomas L., Et Ux				52	L	38	98	136
Rauf, Abdul & Tahmina (Frmrly Forster, J.)				50	L	2,450	710	3,160
Hiatt, Thomas(Hiatt Family Trust)				49, 49.7	L	947	538	1,485
Hiatt, Thomas(Illerich, Phillip)				49	L	372	212	584
Oji, Mitsue Family Partnership				48.7	L	3,430	1,310	4,740
Henle, Thomas N.				46.5	L	935	0	935
Windswept Land&Livestock Co. (P. Burroughs)				44.2, 45.6, 46.45	L	4,040	0	4,040
Schreiner, Joe & Cleo				38.8	L	180	20	200
Munson, James T., Et Ux			37.75	L	70	85	155	
Klsy, Llc (Frmrly Mirbach-Harff Antonius)			37.2	L	80	90	170	
Driver, John A. & Clare M.			36.45	L	150	80	230	
Driver, John A. & Clare M.			36.45	L	6	10	16	
Quad-H Ranches, Inc.			36.2	L	190	310	500	
Giusti, Richard, Et Al.			36.2	L	850	760	1,610	
Drew, Jerry			35.85	L	24	12	36	
Jaeger, William, Et Al.					385	485	870	
Morehead, Joseph Et Ux					115	140	255	
Heidrick, Joe Jr.			33.75	L	360	200	560	
Leiser, Dorothy L.			33.75	L	36	24	60	
Mcm Properties Inc			33.75	L	860	610	1,470	
Richter, Henry D. (Richter Brothers, Et Al.)			33.2	L	1,750	1,030	2,780	
Furlan, Emile, Et Ux			32.5, 33.2	L	570	350	920	
Byrd, Anna C. And Osborne, Jane			26.8, 30.5	L	1,055	200	1,255	
<b>Total</b>	D128					76,633	26,808	103,441
Edson, Wallace L. & Mary O. *	D129A	65	8S	33.85	R	40	64	104
Driver, William A.(Frmrly Collier, T.)				32.5	R	54	106	160
Driver, Gregory E.(Frmrly Collier, T.)				32.5	R	54	106	160
Giovannetti, B.E. & Mary				31.5	R	470	50	520
<b>Total</b>	D129A					618	326	944

**Table 7. Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc location - OCAP Study 7.0 - Existing Conditions**

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)					
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total			
Odysseus Farms Prtnrshp.(Frmrly Leal, Robert)	D162A	70	N/A	19.6	L	220	410	630			
Cummings, Wm. (Frmrly Verona Farming Prtnrshp)				18.7	L	180	120	300			
Lauppe, Burton And Kathryn				18.45	L	720	230	950			
Natomas Basin Conservancy				18.2	L	221	269	490			
E.L.H. Sutter Properties, Inc.				18.2	L	12	28	40			
Lauppe, Burton And Kathryn				18.2	L	153	197	350			
Siddiqui, J.&A.T.				10.75	L	110	20	130			
Willey, Edwin, Mr. And Mrs.				10.75	L	75	20	95			
Siddiqui, Javed&Amna (Et Al.&Fmly.Partnshp.)				10.25	L	860	200	1,060			
Sacramento, County Of				9.3	L	520	230	750			
<b>Total</b>				D162A					3,071	1,724	4,795
Sacramento River Ranches(Fmrly Deseret Farms)				D163	65	N/A	16.6, 17.0, 22.5	R	4,000	0	4,000
Knaggs Walnut Ranches Co. Lp	16.1	R	630				0	630			
Conway Preservation Group	12	R	50,190				672	50,862			
Wilson Ranch Partnership	11.1	R	370				0	370			
Reclamation Dists. 900 And 1000 (Frm.Amen,H.)	9.35	R	281				123	404			
Riverby Limited Partnership	5.25	R	470				30	500			
<b>Total</b>	D163					55,941	825	56,766			
<b>Total</b>						149,298	35,948	185,246			

<sup>a</sup> Source: Settlement contractor data provided by Reclamation

## Appendix D-Attachment 2

### Delivery Specifications: OCAP Study 8.0 (Future)

This attachment describes the State Water Project (SWP) and Central Valley Project (CVP) contract amounts and other water rights assumptions used in the OCAP Study 8.0 - Future.

This document does not include CVP contract or water rights assumptions for the East San Joaquin River Region. Table 1 summarizes the SWP and CVP demands described in this document.

**Table 1 – Summary of SWP and CVP Demand/Contract Assumptions in the OCAP Study 8.0 - Future (TAF/year)**

	North-of-the-Delta	South-of-the-Delta
CVP Contractors		
• Settlement/Exchange	2,194	840
Water Service Contracts		
• Agriculture	378	1,937
• M&I <sup>1</sup>	557	164
• Refuges	189	281
SWP Contractors		
• Feather River Service Area	796	0
Table A		
• Ag	0	1,032
• M&I	114	3,024

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<sup>1</sup> North of Delta CVP M&I demands include Delta demands

## State Water Project

Table 2 shows the SWP Table A amounts and Article 21 demands for each North-of-the-Delta contractor. In addition, the table shows Feather River Service Area water rights.

Table 3 shows the SWP Table A amounts and Article 21 demands for each South-of-the-Delta contractor. In addition, the table shows assumed losses on the California Aqueduct.

## Central Valley Project

Table 4 shows the CVP contract amounts, Settlement Contractor and Exchange Contractor contract amounts, and firm Level 2 refuge water demands for the North-of-the-Delta region. The same type of information for the American River portion of the system is shown separately in Table 5.

Table 6 shows the CVP contract amounts, Settlement Contractor and Exchange Contractor contract amounts, other non-CVP water rights, firm Level 2 refuge water demands, and assumed losses for the South-of-the-Delta region.

Table 7 provides tables that list the CVP Settlement Contractors included in each Sacramento River miscellaneous users delivery arc. These provide additional detail for assumptions contained in Table 4.

**Table 2. SWP North-of-the-Delta - OCAP Study 8.0 - Future**

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	FRSA Amount (TAF)	Water Right (TAF/yr)	Table A Amount (TAF)		Article 21 Demand (TAF/mon)	Other (TAF/yr)
					Ag	M&I		
<b>Feather River</b>								
Palermo	FRSA	D6		17.6				
County of Butte	Feather River	D201				27.5		
Thermalito	FRSA	D202		8.0				
Western Canal	FRSA	D7A	150.0	145.0				
Joint Board	FRSA	D7B	550.0	5.0				
City of Yuba City	Feather River	D204				9.6		
Feather WD	FRSA	D206A	17.0					
Garden, Oswald, Joint Board	FRSA	D206B						
Garden	FRSA	D206BA	12.9	5.1				
Oswald	FRSA	D206BB	2.9					
Joint Board	FRSA	D206BC	50.0					
Plumas, Tudor	FRSA	D206C						
Plumas	FRSA	D206CA	8.0	6.0				
Tudor	FRSA	D206CB	5.1	0.2				
Total Feather River Area			795.8	186.9	0.0	37.1		
<b>Other</b>								
Yuba County Water Agency	Yuba River	D230						Variable 331.4
Camp Far West ID	Yuba River	D285						12.6
South Sutter WD	American R/DSA70	D283						Variable 99.2
Feather River Exports to American River (left bank to DSA70)	American R/DSA70	D223		11.0				
<b>Delta</b>								
Napa County FC&WCD	North Bay Aqueduct	D403B				29.02	1.0	
Solano County WA	North Bay Aqueduct	D403C				47.76	1.0	
Fairfield, Vacaville and Benecia Agreement	North Bay Aqueduct	D403D		31.6				
Total North Bay Aqueduct						76.78	2.0	



**Table 3. SWP South-of-the-Delta - OCAP Study 8.0 - Future**

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Table A Amount (TAF)		Article 21 Demand (TAF/mon)	Losses (TAF/yr)
			Ag	M&I		
Alameda Co. FC&WCD, Zone 7	SBA reaches 1-4	D810		51.74	1.00	
	SBA reaches 5-6	D813		28.88	None	
		Total		80.62	1.00	
Alameda County WD	SBA reaches 7-8	D814		42.00	1.00	
Santa Clara Valley WD	SBA reach 9	D815		100.00	4.00	
Oak Flat WD	CA reach 2A	D802	5.70		None	
County of Kings	CA reach 8C	D847	9.00		None	
Dudley Ridge WD	CA reach 8D	D849	57.34		1.00	
Empire West Side ID	CA reach 8C	D846	3.00		1.00	
Kern County Water Agency	CA reaches 3, 9-13B	D851	600.61	134.60	None	
	CA reaches 14A-C	D859	111.68		180.00	
	CA reaches 15A-16A	D863	62.77		None	
	CA reach 31A	D867	73.07		None	
		Total	848.13	134.60	None	
Tulare Lake Basin WSD	CA reaches 8C-8D	D848	96.23		15.00	
San Luis Obispo Co. FC&WCD	CA reaches 33A-35	D869		25.00	None	
Santa Barbara Co. FC&WCD	CA reach 35	D870		45.49	None	
Antelope Valley-East Kern WA	CA reaches 19-20B, 22A-B	D877		141.40	1.00	
Castaic Lake WA	CA reach 31A	D868	12.70		1.00	
	CA reach 30	D896		82.50	None	
		Total	12.70	82.50	1.00	
Coachella Valley WD	CA reach 26A	D883		133.10	2.00	
Crestline-Lake Arrowhead WA	CA reach 24	D25		5.80	None	
Desert WA	CA reach 26A	D884		54.00	5.00	
Littlerock Creek ID	CA reach 21	D879		2.30	None	
Mojave WA	CA reaches 19, 22B-23	D881		75.80	None	

**Table 3. SWP South-of-the-Delta - OCAP Study 8.0 - Future**

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Table A Amount (TAF)		Article 21 Demand (TAF/mon)	Losses (TAF/yr)
			Ag	M&I		
Metropolitan WDSC	CA reach 26A	D885		778.13	45.35	
	CA reach 30	D895		719.66	37.40	
	CA reaches 28G-H	D899		410.31	13.80	
	CA reach 28J	D27		3.40	3.45	
	Total			1911.50	100.00	
Palmdale WD	CA reaches 20A-B	D878		21.30	None	
San Bernardino Valley MWD	CA reach 26A	D886		102.60	None	
San Gabriel Valley MWD	CA reach 26A	D887		28.80	None	
San Geronio Pass WA	CA reach 26A	D888		17.30	None	
Ventura County FCD	CA reach 29H	D28		3.15	None	
	CA reach 30	D29		16.85	None	
	Total			20.00		
SWP Losses	CA reaches 1-2	D803				7.70
	CA reach 3	D824				10.80
	CA reach 4	D826				2.60
	CA reach 5	D827				3.90
	CA reach 6	D828				1.20
	CA reach 7	D829				1.60
	CA reaches 8C-13B	D854				11.90
	Wheeler Ridge PP and CA reaches 14A-C	D862				3.60
	Chrisman PP and CA reaches 15A-18A	D864				1.80
	Pearblossom PP and CA reaches 17-21	D880				5.10
	Mojave PP and CA reaches 22A-23	D882				4.00
	REC and CA reaches 24-28J	D889				1.40
	CA reaches 29A-29F	D891				1.90
	Castaic PWP and CA reach 29H	D893				3.10
	REC and CA reach 30	D894				2.40
SBA reaches 1-9	D816				0.60	
Total						63.60
Total			1032.10	3024.11	312.00	63.60

**Table 4. CVP North-of-the-Delta - OCAP Study 8.0 - Future**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)
			AG	M&I			
Anderson Cottonwood ID	Sacramento River Redding Subbasin	D104A			128.0		
Clear Creek CSD		D104B	13.8	1.5			
Bella Vista WD		D104C	22.1	2.4			
Shasta CSD		D104D		1.0			
Sac R. Misc. Users		D104F			3.4		
Redding, City of		D104G			21.0		
City of Shasta Lake		D104H	2.5	0.3			
Mountain Gate CSD		D104I		0.4			
Shasta County Water Agency		D104J	0.5	0.5			
Redding, City of/Buckeye		D104K		6.1			
Total		D104	38.9	12.2	152.4		0.0
Corning WD		Corning Canal	D171	23.0			
Proberta WD	D171		3.5				
Thomes Creek WD	D171		6.4				
Total			32.9	0.0	0.0		0.0
Kirkwood WD	Tehama-Colusa Canal	D172	2.1				
Glide WD		D174	10.5				
Kanawha WD		D174	45.0				
Orland-Artois WD		D174	53.0				
Colusa, County of		D178	20.0				
Colusa County WD		D178	62.2				
Davis WD		D178	4.0				
Dunnigan WD		D178	19.0				
La Grande WD		D178	5.0				
Westside WD		D178	65.0				
Total		285.8	0.0	0.0		0.0	
Sac. River Misc. Users	Sacramento River	D113A			1.5		
Glenn Colusa ID	Glenn-Colusa Canal	D143A			825.0		
Sacramento NWR		D143B					53.4
Delevan NWR		D145B					24.0
Colusa NWR		D145B					28.8
Colusa Drain M.W.C.	Colusa Basin Drain	D180 D182A/ D18302			70.0		
Total			0.0	0.0	895.0		106.2

**Table 4. CVP North-of-the-Delta - OCAP Study 8.0 - Future**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)
			AG	M&I			
Princeton-Cordova-Glenn ID	Sacramento River	D122A			67.8		
Provident ID		D122A			54.7		
Maxwell ID		D122A			18.0		
		D122B					
Sycamore Family Trust		D122B			31.8		
Roberts Ditch IC		D122B			4.4		
Sac R. Misc. Users		D122A			4.9		
		D122B			9.5		
<b>Total</b>			0.0	0.0	191.2		0.0
Reclamation District 108	Sacramento River	D122B			232.0		
		D129A					
River Garden Farms		D129A			29.8		
Meridian Farms WC		D128			35.0		
Pelger Mutual WC		D128			8.9		
Reclamation District 1004		D128			71.4		
Carter MWC		D128			4.7		
Sutter MWC		D128			<b>226.0</b>		
Tisdale Irrigation & Drainage Co.		D128			9.9		
		D128			103.4		
Sac R. Misc. Users		D129A			0.9		
Feather River WD export		D128	20.0				
<b>Total</b>				20.0	0.0	722.1	
Sutter NWR	Sutter bypass water for Sutter NWR	C136B					25.9
Gray Lodge WMA	Feather River	C216B					41.4
Butte Sink Duck Clubs		C221					15.9
<b>Total</b>			0.0	0.0	0.0		83.2

**Table 4. CVP North-of-the-Delta - OCAP Study 8.0 - Future**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)
			AG	M&I			
Sac R. Misc. Users	Sacramento River	D163			56.8		
City of West Sacramento		D165			23.6		
Total				0.0	0.0	80.4	
Sac R. Misc. Users	Lower Sacramento River	D162A			4.8		
Natomas Central MWC		D162B			120.2		
Pleasant Grove-Verona MWC		D162C			26.3		
City of Sacramento (PCWA)		D162D				81.8	
PCWA (Water Rights)		D162E				60.0	
Total					151.3	141.8	
City of Vallejo	City of Vallejo	D403A		16.0			
CCWD <sup>c</sup>	Contra Costa County	D408		195.0 <sup>c</sup>			
Total				211.0			
Total CVP North-of-Delta			377.6	223.2	2193.8	141.8	189.4

<sup>a</sup> Level 4 Refuge water needs are not included.

<sup>b</sup> Refer to Table 7 for more information

<sup>c</sup> The new Los Vaqueros module in CALSIM II is used to determine the range of demands that are met by CVP contracts or other water rights.

**Table 5. CVP and Water Rights for American River - OCAP Study 8.0 - Future**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement/ Exchange Contractor (TAF/yr)	Water Rights/ Non-CVP (TAF/yr)	Folsom Unimpaired Inflow (FUI) (TAF/yr)			Foot-notes (on following page)	
			AG	M&I			If FUI (Mar-Nov Folsom Unimpaired Inflow - TAF/yr)				
							> 1600	> 950	< 400		
Placer County Water Agency	Auburn Dam Site	D300		0.0		35.5	35.5	35.5	35.5	1/2/3	
City of Folsom (includes P.L. 101-514)	Folsom Reservoir	D8B		7.0		27.0	34.0	34.0	34.0	1/2/3	
Folsom Prison		D8C				5.0	5.0	5.0	5.0		
San Juan Water District (Placer County)		D8D				24.0	24.0	24.0	24.0	1/2/3/10	
San Juan Water District (Sac County) (includes P.L. 101-514)		D8E		24.2		33.0	57.2	57.2	57.2	1/2/3	
El Dorado Irrigation District		D8F		7.55		17.0	24.55	24.55	22.55	1/2/3	
City of Roseville		D8G		32.0		0.0	32.0	32.0	32.0	1/2/3/10	
Placer County Water Agency		D8H		35.0			35.0	35.0	35.0		
El Dorado County (P.L. 101-514)		D8I		15.0			15.0	15.0	15.0		
<b>Total</b>				<b>0.0</b>	<b>120.8</b>	<b>0.0</b>	<b>106.0</b>	<b>226.8</b>	<b>226.8</b>	<b>224.8</b>	
So. Cal WC/ Arden Cordova WC		Folsom South Canal	D9AA				5.0	5.0	5.0	5.0	
California Parks and Recreation	D9AB			5.0			5.0	5.0	5.0		
SMUD (export)	D9B			30.0		15.0	45.0	45.0	45.0	1/2/3	
Canal Losses	D9A					1.0	1.0	1.0	1.0		
<b>Total</b>				<b>0.0</b>	<b>35.0</b>	<b>0.0</b>	<b>21.0</b>	<b>56.0</b>	<b>56.0</b>	<b>56.0</b>	
City of Sacramento	Lower American River	D302A & D167A				230.0	230.0	230.0	50.0	6/7/8	
Arcade Water District		D302B				0.0	0.0	0.0	0.0	13	
Carmichael Water District		D302C				12.0	12.0	12.0	12.0		
<b>Total</b>				<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>242.0</b>	<b>242.0</b>	<b>242.0</b>	<b>62.0</b>	
Sacramento County Water Agency (SMUD transfer)		D167B/D168B		30.0			30.0	30.0	30.0	9	
Sacramento County Water Agency (P.L. 101-514)		D168B		15.0			15.0	15.0	15.0	9	
Sacramento County Water Agency - assumed Appropriated Water		D168B								9,11	
EBMUD (export)		D168C		133.0			133.0			12	
<b>Total</b>				<b>0.0</b>	<b>178.0</b>	<b>0.0</b>	<b>0.0</b>	<b>178.0</b>	<b>45.0</b>	<b>45.0</b>	
<b>Total</b>			<b>0.0</b>	<b>333.8</b>	<b>0.0</b>	<b>404.5</b>	<b>738.3</b>	<b>605.3</b>	<b>423.3</b>		

**Table 5. CVP and Water Rights for American River - OCAP Study 8.0 - Future**

- 1/ *Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 950 TAF*
- 2/ *Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 950 TAF but greater than 400 TAF*
- 3/ *Driest years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 400 TAF*
- 4/ *Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 1,600,000 af.*
- 5/ *Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 1,600 TAF*
- 6/ *Diversions for the City of Sacramento occur at the E. A. Fairbairn Water Treatment Plant if American River flows exceed the "Hodge flows H Street criteria" (Wet to Normal).*
- 7/ *Diversions for the City of Sacramento occur off the Sacramento River when American River flows do not exceed the "Hodge flows H Street criteria".(Dry to Critical)*
- 8/ *For modeling purposes, it is assumed that the City of Sacramento's total annual diversions from the American River in year 2030 would be 230 TAF*
- 9/ *The total buildout demand for Sacramento County Water Agency is 108 TAF. Of this, an average of 68 TAF of surface water is needed annually, with the remaining 40 TAF/yr coming from groundwater supplies.*
- 10/ *Water Rights Water provided by releases from PCWA's Middle Fork Project; inputs into upper American River model must be consistent with these assumptions.*
- 11/ *SCWA targets 68 TAF of surface water supplies annually. The portion unmet by CVP contract water is assumed to come from two sources:
  - (1) *Delta "excess" water- averages 14.9 TAF annually, but varies according to availability. SCWA is assumed to divert excess flow in the Delta when it is available, and when it has the available pumping capacity.*
  - (2) *"Other" water- derived from transfers and/or other appropriated water, averaging 14 TAF annually but varying according to availability of Excess and CVP water.**
- 12/ *EBMUD CVP diversions are governed by the Amendatory Contract, stipulating:
  - (1) *133 TAF maximum diversion in any given year*
  - (2) *165 TAF maximum diversion amount over any 3 year period*
  - (3) *Diversions allowed only when EBMUD total storage drops below 500 TAF*
  - (4) *155 cfs maximum diversion rate**
- 13/ *Arcade WD demand was combined with the City of Sacramento demands.*

**Table 6. CVP South-of-the-Delta - OCAP Study 8.0 - Future**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)	Losses (TAF/yr)
			AG	M&I				
Byron-Bethany ID	Upper DMC	D700	20.6					
Tracy, City of		D700		10.0				
		D700		5.0				
		D700		5.0				
Banta Carbona ID		D700	20.0					
Total	D700	40.6	20.0	0.0	0.0	0.0	0.0	
Del Puerto WD	Upper DMC	D701	12.1					
Davis WD		D701	5.4					
Foothill WD		D701	10.8					
Hospital WD		D701	34.1					
Kern Canon WD		D701	7.7					
Mustang WD		D701	14.7					
Orestimba WD		D701	15.9					
Quinto WD		D701	8.6					
Romero WD		D701	5.2					
Salado WD		D701	9.1					
Sunflower WD		D701	16.6					
West Stanislaus WD		D701	50.0					
Patterson WD		D701	16.5			6.0		
Westlands WD #1 (Centinella WD)		D701	0.0					
Total		D701	206.7	0.0	0.0	6.0	0.0	0.0
Upper DMC Loss	Upper DMC	D702						18.5
Panoche WD	Lower DMC Volta	D706	6.6					
San Luis WD		D706	65.0					
Broadview WD		D706	0.0					
Laguna WD		D706	0.8					
Eagle Field WD		D706	4.6					
Mercy Springs WD		D706	2.8					
Westlands WD #2		D708	0.0					
Oro Loma WD		D706	4.6					
Westlands WD #1 (Widren WD)		D706	0.0					
Total		D706	84.4	0.0	0.0	0.0	0.0	0.0
Upper DMC Exchange Contractors	Lower DMC Volta	D707						
Central California ID		D707			140.0			
Grasslands via CCID	Lower DMC Volta	D708					<b>81.8</b>	
Los Banos WMA		D708					<b>11.2</b>	



**Table 6. CVP South-of-the-Delta - OCAP Study 8.0 - Future**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)	Losses (TAF/yr)
			AG	M&I				
Kesterson NWR	Lower DMC Volta	D708					10.5	
Freitas - SJBAP		D708					6.3	
Salt Slough - SJBAP		D708					8.6	
China Island - SJBAP		D708					7.0	
Volta WMA		D708					13.0	
Grassland via Volta Wasteway		D708					23.2	
<b>Total</b>		D708	0.0	0.0	0.0	0.0	161.5	0.0
Westlands WD (incl. Barcellos)	Mendota Pool	D607A	0.0					
Fresno Slough WD		D607A/D607B	4.0			0.9		
James ID		D607A/D607B	35.3			9.7		
Coelho Family Trust		D607A/D607B	2.1			1.3		
Tranquillity ID		D607A/D607B	13.8			20.2		
Tranquillity PUD		D607A/D607B	0.1			0.1		
Reclamation District 1606		D607A/D607B	0.2			0.3		
Exchange Contractors		D607B						
Central California ID		D607B			392.4			
Columbia Canal Co.		D607B			59.0			
Firebaugh Canal Co.		D607B			85.0			
San Luis Canal Co.		D607B			163.6			
M.L. Dudley Company		D607B				2.3		
Grasslands WD		D607C					31.3	
Los Banos WMA		D607C					12.4	
San Luis NWR		D607C					19.5	
Mendota WMA		D607C					27.6	
West Bear Creek NWR		D607C					7.5	
East Bear Creek NWR		D607C					8.9	
Losses		D607D						101.5
<b>Total</b>	D607	55.5	0.0	700.0	34.8	107.3	101.5	
San Benito County WD (Ag)	San Felipe	D710	35.6					
Santa Clara Valley WD (Ag)		D710	33.1					
Pajaro Valley WD		D710	6.3					
San Benito County WD (M&I)		D711		8.3				
Santa Clara Valley WD (M&I)		D711		119.4				
<b>Total</b>		D710/D711	74.9	127.7	0.0	0.0	0.0	0.0



**Table 6. CVP South-of-the-Delta - OCAP Study 8.0 - Future**

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges <sup>a</sup> (TAF/yr)	Losses (TAF/yr)	
			AG	M&I					
Cross Valley Canal - CVP	CA reach 14								
Fresno, County of		D855	3.0						
Hills Valley ID-Amendatory		D855	3.3						
Kern-Tulare WD		D855	40.0						
Lower Tule River ID		D855	31.1						
Pixley ID		D855	31.1						
Rag Gulch WD		D855	13.3						
Tri-Valley WD		D855	1.1						
Tulare, County of		D855	5.3						
Kern NWR		D856					11.0		
Pixley NWR		D856					1.3		
Total				128.3	0.0	0.0	0.0	12.3	0.0
Total CVP South-of-Delta				1936.9	164.2	840.0	44.3	281.1	183.7

<sup>a</sup> Level 4 Refuge water needs are not included

**Table 7. - Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc locationa - OCAP Study 8.0 - Future**

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)				
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total		
Riverview Golf & Country Club	D104F	58	3	240.8	L	255	25	280		
Daniell, Harry				240.3	L	13	7	20		
Redding Rancheria (Fmrly High-Low Nursery)				240.2	L	70	135	205		
Lake Cal. Property Owners Assn			2	221	R	580	200	780		
Leviathan, Inc.				221	R	355	345	700		
Driscoll Strawberry Associates, Inc.				207.5	L	330	490	820		
J. B. Unlimited, Inc.			3	197	L	220	290	510		
Micke, Daniel & Nina				196.6	L	81	19	100		
Gjermann, Hal				196.55	L	8	4	12		
<b>Total</b>			D104F					1,912	1,515	3,427
Meyer, Herbert (Fmrly Diamond Holdings, Inc.)	D113A	58	4	191.5	R	195	230	425		
Exchange Bank (The Nature Conservancy)				168.85	R	210	570	780		
Rubio, Exequiel (Fmrly Elliott&Hadracky)				166.8	R	11	5	16		
Penner, Roger & Leona				156.8	R	159	21	180		
Freeman, Vola				156.1	R	11	19	30		
Mclane, Robert				155.6	R	17	23	40		
Alexander, Thomas Et Ux				155.6	R	9	13	22		
<b>Total</b>				D113A					612	881
Green Valley Corp. (Fmrly Cannell, F.)	D122A	15	8NN	106	R	680	210	890		
Green Valley Corp. (Fmrly Stegeman Ranch)				106	R	555	325	880		
Tuttle, Charles W. - Trust				103.9	R	120	270	390		
Cachil Dehe Band Of Wintun Indians(Lee Farms)				103.7	R	80	100	180		
Seaver, Charles				99.3	R	200	260	460		
Odysseus Farms				93.15	R	1,920	150	2,070		
<b>Total</b>				D122A					3,555	1,315
King, Ben And Laura (Fmrly Dommer, E.)	D122B	15	8NS	89.2	R	12	7	19		
King, Laura				89.2	R	13	13	26		
Wisler, John W. Jr. (Fmrly Cribari, E.)				88	R	8	27	35		
Mehrhof, Susan M.(fmrly.Swinford Tract)				87.7	R	164	16	180		
Steidlmayer, Anthony E., Et Al.				83	R	610	700	1,310		
Jansen, Peter & Sandy (Fmrly E. J. Ritchey)				70.4	R	150	40	190		
Gillaspy, William & Mary (Fmrly Fay Gillaspy)				70.4	R	120	90	210		
Beckley, Ralph, And Ophelia				70.4	R	165	135	300		
Driver, Gary, Et Al.				69.2	R	8	22	30		
Heidrick, Mildred M.				30.6	R	86	34	120		
Tenhunfeld, F. Wallace, Jack, Et Al.		65		29.7	R	2,680	960	3,640		
Heidrick, Mildred M.				29.2, 30.3	R	370	60	430		
Hershey Land Company				28.1	R	2,570	450	3,020		
<b>Total</b>				D122B					6,956	2,554

**Table 7. - Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc locationa - OCAP Study 8.0 - Future**

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)				
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total		
Pacific Realty Assoc., L.P. (M&T Chico Ranch)	D128	15	9	140.8, 141.5	L	16,980	976	17,956		
Spence, Ruth Ann (Spence Farms)				104.8	L	630	100	730		
Anderson, Arthur Et Al (Frmrly Westfall, Mary)				102.5	L	445	45	490		
Forry, Laurie E.				99.8	L	2,285	0	2,285		
Otterson, Mike (Frmrly Wells Joyce M.)				98.9	L	1,515	300	1,815		
Nene Ranch, Llc (Frmrly Hollins, Mariette B.)				98.6	L	1,360	200	1,560		
Griffin, Josphe, Et Al.				95.8	L	1,610	1,150	2,760		
Baber, Jack Et Al.				95.6	L	3,630	2,630	6,260		
Eastside Mwc (Frmrly A&F Boeger Corp.)				95.25	L	2,170	634	2,804		
Zelmar Ranch, Inc. (Frmrly Martin, Andrew)				92.5	L	112	52	164		
Gomes, Judith (Frmrly. Martin, Andrew)				92.5	L	168	78	246		
Butte Creek Farms				89.26	L	20	16	36		
Butte Creek Farms				89.24	L	40	55	95		
Butte Creek Farms (Frmrly Mayfair Farms)				88.7	L	196	8	204		
Butte Creek Farms(Area 1)				88.7	L	300	340	640		
Howard, Theordore W. And Linda M.				88.7	L	74	2	76		
Locvich, Paul				88.2	L	80	70	150		
Ehrke, Allen A. Et Ux				86.8	L	220	160	380		
Fedora, Sib Et Al.			82.7	L	190	20	210			
Reische, Laverne Et Ux			82.5	L	183	267	450			
Reische, Eric			82.5	L	37	53	90			
Tarke, Stephen & Debra			81.5	L	1,700	1,000	2,700			
Churkin, Michael, Et Al.			79.5	L	75	55	130			
Eggleston, Ronald Et Ux			79	L	53	12	65			
Hale, Judith Et Al.			79	L	117	13	130			
Hale, Judith Et Al.			79	L	58	17	75			
Pires, Lawrence And Beverly			77.9	L	185	95	280			
Davis, Ina M.			76.2	L	71	14	85			
Chesney, Adona (R & A, Bypass Trust)			76.15	L	310	390	700			
Andreotti, Beverly F., Et Al.			72.1	L	2,060	1,560	3,620			
Mclaughlin, Jack			72	L	430	220	650			
Lomo Cold Storage (& J. J. Micheli)			67.5	L	6,410	700	7,110			
Anderson, R And J, Prop.			67.1	L	149	88	237			
Lonon, Michael Et Al.			67.1	L	715	440	1,155			
Oji Brothers Farm, Inc.			63.9	L	1,340	1,860	3,200			
Young, Russell, Et Al.			63.3	L	2	8	10			
Sekhon, Arjinderpal & Daljit			62.3	L	350	470	820			
Butler, Leslie A., Et Ux			60.5, 61.8	L	180	280	460			
Howald Farms Inc.			60.4	L	1,350	1,410	2,760			
Kary, Carol			59.8	L	400	600	1,000			
					18					

**Table 7. - Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc locationa - OCAP Study 8.0 - Future**

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Dennis Wilson Farms (Frmrly M&L Farms (Area 1))	D128	15	19	58.9	L	295	60	355
Lockett, William P. & Jean B.				58.3	L	370	47	417
O'brien, Janice				58.3	L	550	289	839
Wirth, Marilyn L. (Frmrly Davis, Marilyn)				57.75	L	180	340	520
Bardis, C. Et Al 9(Reynen/Broomieside Farms)				55.1	L	8,070	2,000	10,070
Wakida, Tomio				53.9	L	50	275	325
Wakida, Tomio				52.3	L	25	135	160
Nelson, Thomas L., Et Ux				52	L	38	98	136
Rauf, Abdul & Tahmina (Frmrly Forster, J.)				50	L	2,450	710	3,160
Hiatt, Thomas(Hiatt Family Trust)				49, 49.7	L	947	538	1,485
Hiatt, Thomas(IIlerich, Phillip)				49	L	372	212	584
Oji, Mitsue Family Partnership				48.7	L	3,430	1,310	4,740
Henle, Thomas N.				46.5	L	935	0	935
Windswept Land&Livestock Co. (P. Burroughs)				44.2, 45.6, 46.45	L	4,040	0	4,040
Schreiner, Joe & Cleo				38.8	L	180	20	200
Munson, James T., Et Ux			37.75	L	70	85	155	
Klsy, Llc (Frmrly Mirbach-Harff Antonius)			37.2	L	80	90	170	
Driver, John A. & Clare M.			36.45	L	150	80	230	
Driver, John A. & Clare M.			36.45	L	6	10	16	
Quad-H Ranches, Inc.			36.2	L	190	310	500	
Giusti, Richard, Et Al.			36.2	L	850	760	1,610	
Drew, Jerry			35.85	L	24	12	36	
Jaeger, William, Et Al.					385	485	870	
Morehead, Joseph Et Ux					115	140	255	
Heidrick, Joe Jr.			33.75	L	360	200	560	
Leiser, Dorothy L.			33.75	L	36	24	60	
Mcm Properties Inc			33.75	L	860	610	1,470	
Richter, Henry D. (Richter Brothers, Et Al.)			33.2	L	1,750	1,030	2,780	
Furlan, Emile, Et Ux			32.5, 33.2	L	570	350	920	
Byrd, Anna C. And Osborne, Jane			26.8, 30.5	L	1,055	200	1,255	
Total	D128					76,633	26,808	103,441
Edson, Wallace L. & Mary O. *	D129A	65	8S	33.85	R	40	64	104
Driver, William A.(Frmrly Collier, T.)				32.5	R	54	106	160
Driver, Gregory E.(Frmrly Collier, T.)				32.5	R	54	106	160
Giovannetti, B.E. & Mary				31.5	R	470	50	520
Total	D129A					618	326	944

**Table 7. - Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc locationa - OCAP Study 8.0 - Future**

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Odysseus Farms Prtnrshp.(Frmrly Leal, Robert)	D162A	70	N/A	19.6	L	220	410	630
Cummings, Wm. (Frmrly Verona Farming Prtnrshp)				18.7	L	180	120	300
Lauppe, Burton And Kathryn				18.45	L	720	230	950
Natomas Basin Conservancy				18.2	L	221	269	490
E.L.H. Sutter Properties, Inc.				18.2	L	12	28	40
Lauppe, Burton And Kathryn				18.2	L	153	197	350
Siddiqui, J.&A.T.				10.75	L	110	20	130
Willey, Edwin, Mr. And Mrs.				10.75	L	75	20	95
Siddiqui, Javed&Amna (Et Al.&Fmly.Partnshp.)				10.25	L	860	200	1,060
Sacramento, County Of				9.3	L	520	230	750
<b>Total</b>				D162A				
Sacramento River Ranches(Frmrly Deseret Farms)	D163	65	N/A	16.6, 17.0, 22.5	R	4,000	0	4,000
Knaggs Walnut Ranches Co. Lp				16.1	R	630	0	630
Conway Preservation Group				12	R	50,190	672	50,862
Wilson Ranch Partnership				11.1	R	370	0	370
Reclamation Dists. 900 And 1000 (Frm.Amen,H.)				9.35	R	281	123	404
Riverby Limited Partnership				5.25	R	470	30	500
<b>Total</b>	D163					55,941	825	56,766
<b>Total</b>						149,298	35,948	185,246

<sup>a</sup> Source: Settlement contractor data provided by Reclamation

## Appendix D-Attachment 3

### CalSim-II X2 Analysis

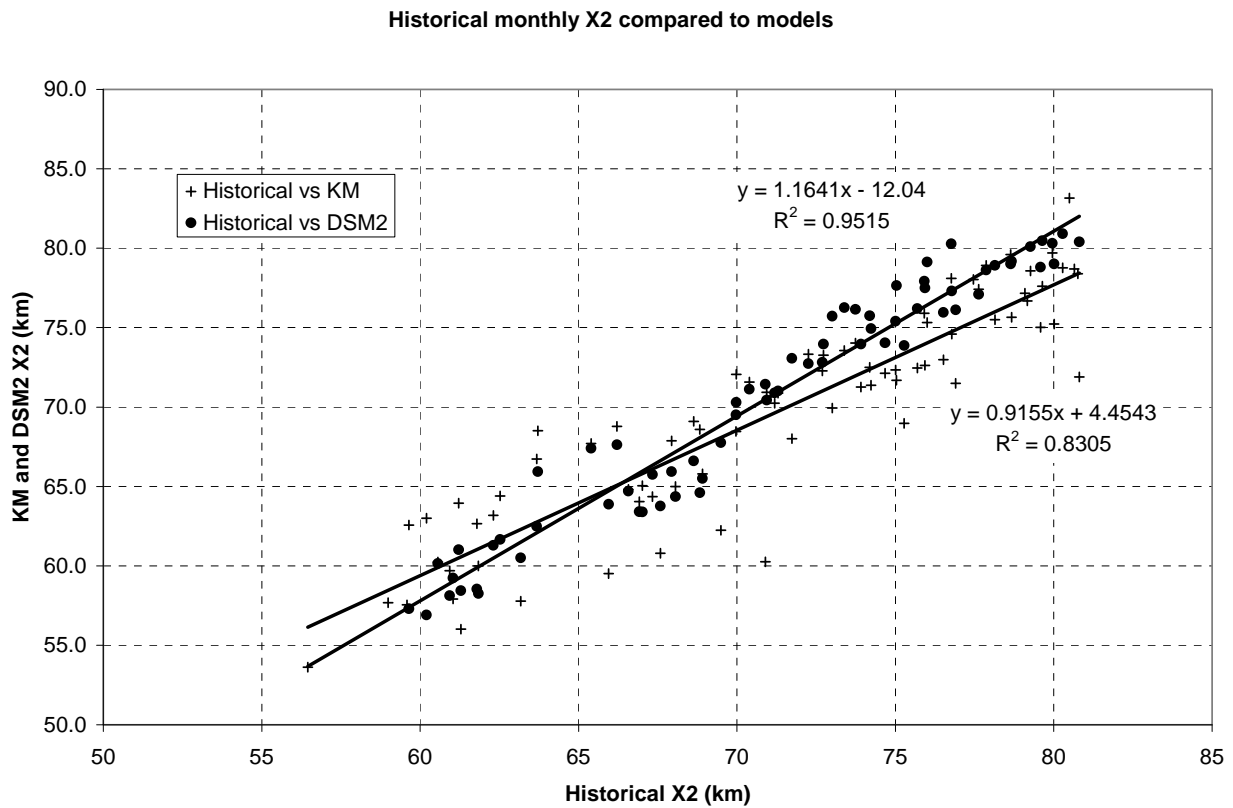
Historically CalSim-II has always used an empirical equation developed by Kimmerer and Monismith (Kimmerer 1993) to estimate the monthly X2. However recent developments with the Artificial Neural Network (ANN) that CalSim-II uses for other salinity compliance has allowed for the use of the ANN to estimate the X2.

To show that the new implementation could replace the previously accepted Kimmerer and Monismith (KM) equation, two sets of comparisons were completed. One set looked at the ability of the Delta Simulation Model 2 (DSM2) and the KM equation to estimate historical calculated X2. The other set of comparisons looked at the ability of the ANN and the KM equation to estimate DSM2 in planning mode.

CalSim-II is a monthly model therefore the comparisons were on a monthly scale as well. For historical and DSM2 data X2 was determined by interpolating between four salinity monitoring stations to find that approximate location of 2.64 mmhos/cm. The four stations and respective distance from the Golden Gate are: Martinez at 56 km, Port Chicago (Roe Island) at 64 km, Chipps Island (Mallard Slough) at 74 km, and Collinsville at 81 km. The hourly electrical conductivity measurements for the historical data spanned 1997 to 2008 and were aggregated to monthly. DSM2 was run using historical inflows for a similar period and the 15 minute data were aggregated to monthly. The KM equation is based on a monthly time-step and so historical daily outflow data was aggregated to monthly and used in the equation.

Figure 1 shows the comparison between historical X2 and DSM2 as well as the KM equation based on historical outflow. The comparison between historical and DSM2 resulted in a slope of 1.16, an intercept of -12.0, and a  $R^2$  of 0.95. The comparison between historical and the KM equation resulted in a slope of 0.92, an intercept of 4.5, and a  $R^2$  of 0.83. From the comparison it is not easy to determine which relationship is more appropriate. We would like to see a slope of 1.0 and an intercept of 0 in order to have the best predictive model.

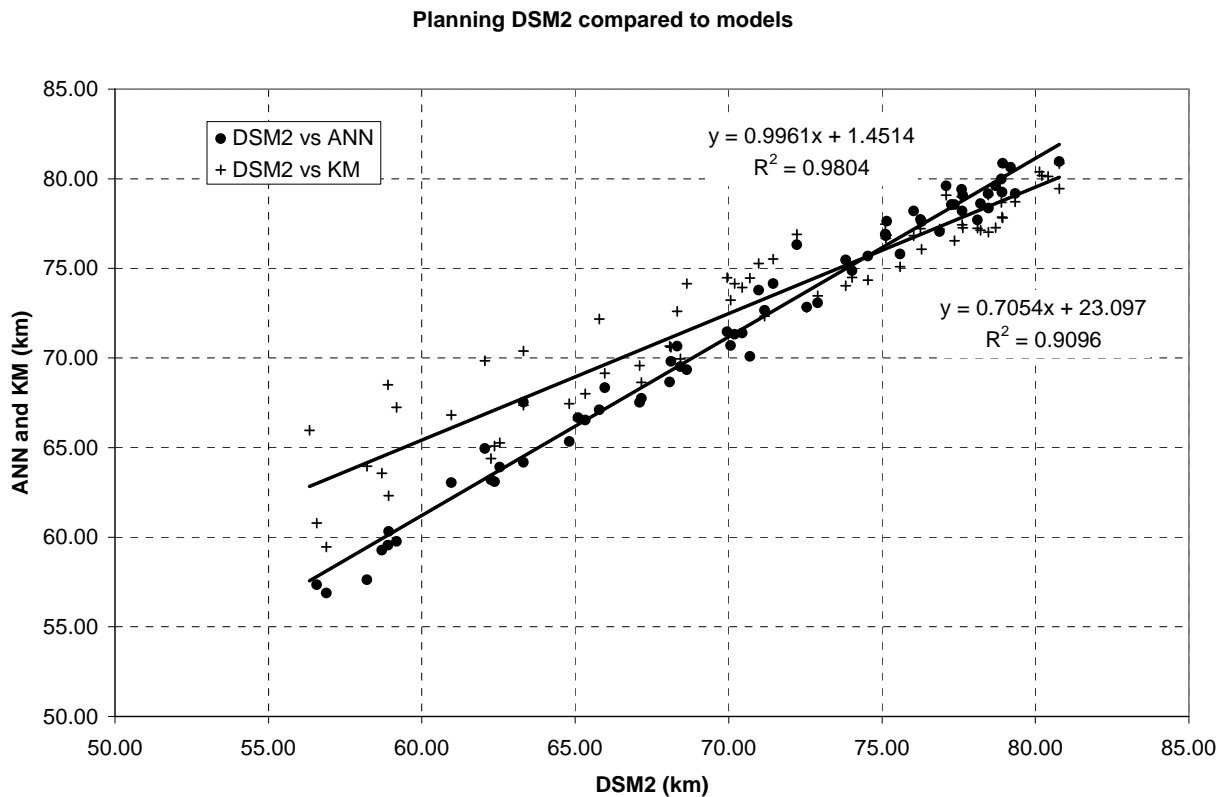




**Figure 1 Historical comparison of X2.**

The next set of comparisons compared DSM2 to the CalSim-II based ANN and KM equation. DSM2 was run using the same CalSim-II run from which the KM equation and ANN X2 results are being compared.

Figure 2 shows the comparison between DSM2 X2 and CalSim-II based KM and ANN X2. The comparison between DSM2 and the ANN resulted in a slope of nearly 1.0, an intercept of 1.5 and a  $R^2$  of 0.98. The comparison between DSM2 and the KM equation resulted in a slope of 0.71, an intercept of 23.1, and a  $R^2$  of 0.91



**Figure 2 Planning comparison of X2**

**Assumptions:**

- Historical and DSM2 estimates are made using a linear interpolation of the surface salinity to determine the approximate location of X2 (2.64 mmhos/cm surface salinity). A dispersion based interpolation may have been a better approximation, however due to time constraints a linear interpolation to find the location of X2 was used. This method of linear approximation may skew the resulting X2 towards a slightly higher value as compared to a dispersive interpolation which incorporates an exponential relationship. This may explain some of the differences seen in Figure 1.
- Planning DSM2 used a salinity boundary estimated using a modified G-Model approach (Ateljevich 2001). The G-Model estimates salinity and incorporates antecedent conditions into the estimate. The ANN was trained on this type of DSM2 and incorporates the following input parameters:
  - Northern flows: Sacramento River + Yolo Bypass + East streams + Calaveras - North Bay & Vallejo Exports

- San Joaquin River Flow
  - Exports: Banks, Tracy, Contra Costa Exports
  - Delta Cross Channel Gate
  - Net Delta Consumptive Use
  - Tidal Energy (daily maximum – minimum from hourly astronomical tide)
  - 117 days antecedent conditions
- When using these methods (ANN and KM equation) to estimate X2 on a monthly time-step it becomes difficult to incorporate the salinity response, or antecedent conditions, due to actions occurring on a daily time-step. For example X2 maybe required for 5 days at Port Chicago (Roe Island) and 25 days at Chipps Island (Mallard Slough) the X2 estimate for Chipps Island should include the fresher conditions induced by the higher X2 requirement. Antecedent conditions have appropriately been incorporated to address this issue.

## References:

- Ateljevich, E. 2001. *Chapter 11: Improving salinity estimates at the Martinez boundary. In Methodology for flow and salinity estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. August. 22nd Annual Progress Report to the State Water Resources Control Board.* California Department of Water Resources. Sacramento, CA
- Kimmerer, W. and Monismith, S. 1993. *An Estimate of the Historical Position of 2 PPT Salinity in the San Francisco Bay (August 1992).* San Francisco Estuary Project, U.S. Environmental Protection Agency, San Francisco.
- SWRCB. 2000. *Revised Water Right Decision 1641.* State Water Resources Control Board, California Environmental Protection Agency, State of California.